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Executive Summary

1 Contribution of Geothermal Energy for Regional Innovation and Earthquake Recovery

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Geothermal heat is a renewable energy resource abundant in Japan, and it has a higher power generation potential than solar or wind power. The geothermal resources equivalent to geothermal power generation is estimated to be around 23GW (more than about 10% of the current electric power capacity of general electric power suppliers in Japan), which is the third highest in the world. However, the capacity of existing geothermal power plants is only 540MW, and there is substantial capability for increase. Compared to other renewable energy sources, geothermal energy characteristically provides not only electricity but also a substantial amount of heat. Approximately half of household electricity is used to generate heat for hot water and air heating, and geothermal heat has an advantage since it can be directly supplied as heat energy sources. In addition, since climate does not affect geothermal power like it does solar and wind power, geothermal power can provide a stable source of energy. Geothermal energy can also contribute to improving energy self-sufficiency rates and reducing CO_2 emissions. It is a sustainable energy source that can be locally produced and consumed and support the region.

As such, geothermal heat is not only a new sustainable source of energy but also has the potential to improve energy efficiency, and to bring new industries to regions. The widespread use of geothermal energy has great potential to make regional contributions and is expected to, through direct and indirect factors, bring new employment opportunities to residents, increase the number of visitors, and contribute to the regional economy. In fact, there are some areas in Japan where their energy self-sufficiency rates are over 100% through the use of geothermal energy.

In particular, the Tohoku region, where is working towards recovering from the massive earthquake, has abundant geothermal energy resources. Since it has a relatively cold climate, the region will benefit more from a sustainable heat supply compared to regions with more moderate climates. Of course, it is important to create large-scale and centralized geothermal energy plants, but construction takes a long time. As such, it is desirable to start using geothermal energy that can be attained in a relatively short period through, for example, binary power generation and hot-spring power generation.

To smoothly develop geothermal energy, it would be most effective to create a system where each region makes its own comprehensive plan for the future, based on geothermal power generation and the national government supports the plan, rather than having individual parties developing power generation business plans. It is desirable to look at cases in other countries as we revise laws and support technological development. Using geothermal energy as an essential heat supply source on a daily basis and building a community based on geothermal power generation with support from the government can create a low-carbon society and lead to regional vitalization. To this end, it is desirable for the government to revise laws, including the Natural Park Law and the Hot Spring Law, shorten the environmental assessment process, and support technological development.

(Original Japanese version: published in November, December 2011)

2 Trends and Problems of Seismological Research in Japan in Light of Two Major

p.29

During the 20th century, Japan experienced earthquakes resulting in ten or more people killed or missing at an average rate of one every 3.2 years. These earthquakes continue to occur at this pace as we enter the 21st century.

The M9 Great East Japan Earthquake that occurred on March 11, 2011 inflicted the heaviest seismic and tsunami damage since the end of World War II and led to a nuclear accident, creating serious problems for the entire country. The Headquarters for Earthquake Research Promotion (HERP) issued a warning beforehand that the coast of Miyagi Prefecture had the highest likelihood of experiencing an M7-M8 earthquake. However, no one had thought that a massive M9 earthquake would strike. This incident was a major shock to those working in the field of seismology. What sorts of effects will this earthquake have on seismology?

The 1995 Great Hanshin-Awaji Earthquake led to big changes in Japanese seismology. However, the results of a comparison between the Seismological Society of Japan's (SSJ) research presentation titles at the regular meeting held in fall 1994 after the Great Hanshin-Awaji Earthquake and the fall 2010 meeting just prior to the Great East Japan Earthquake show little change. On the other hand, a comparison with the Seismological Society of America (SSA) allows us to infer that there is a systematic difference in presentation trends between the two countries. The same impression is made by how sessions are put together. These differences are a contrast in the sense of mission observed in research trends. SSA presentations seem to have a strong mission orientation.

The 4th Science and Technology Basic Plan questions whether science and technology as a whole are making concrete contributions to the various issues that concern the lives of the Japanese people. Accordingly, the author believes that research evaluation methods should determine the direction that research takes. If Japan is to demand a higher sense of mission from seismology, then it will not be enough to only revise project research evaluations. Rather, the author believes that we will need to reconsider how individual researchers are evaluated. This problem is related to the ability of the people managing research and the task at hand is to ask them to display true leadership.

(Original Japanese version: published in November, December 2011)

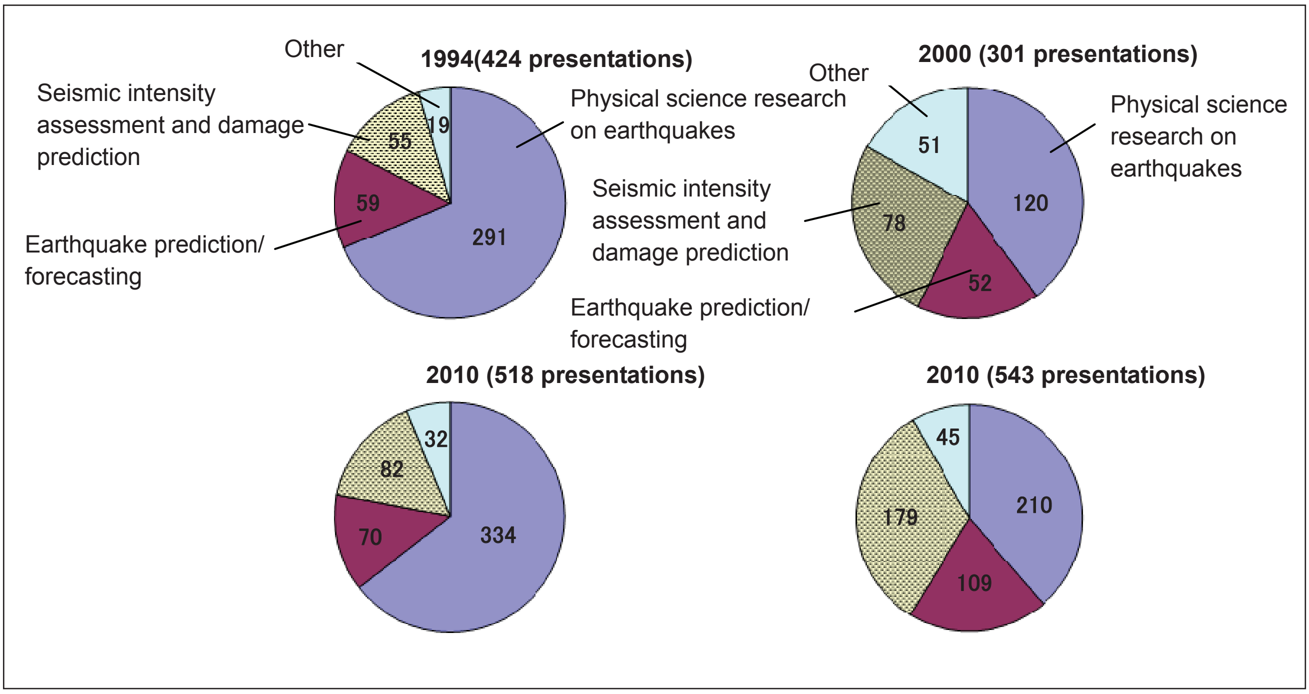

Figure : Seismological Society Presentation Themes Based on Presentation Titles (Left: USA, Right: Japan)
Figures are number of presentations

Compiled by STFC

3 Expansion of Market Mechanisms that Sustain Ecosystem Services - Certification Systems to Promote Ecosystem Conservation in Daily Consumption -

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Humanity receives the benefits provided by ecosystems, called “ecosystem services,” that make our lives plentiful and comfortable. Biodiversity is what supports these ecosystems. Much of our everyday lives, from public services to business, are made up of ecosystem services. However, according to the Survey on Environmentally Friendly Corporate Behaviors released by the Ministry of the Environment in December 2010, only a small percentage of companies in Japan consider it important to preserve biodiversity. The reason is that the tools and indicators to overview the relationship between business and ecosystem services are not in general use.

Some companies have taken the lead by implementing efforts according to frameworks developed around supply chains and business life cycles in order to obtain an overview of these relationships. Additionally, frameworks have been formulated to analyze each industries’ impact and dependency on ecosystems, providing business insiders advance recognize of the macro-level relationship between business and ecosystem services. Certification systems meant to preserve biodiversity and conserve ecosystem services are a means to encourage ecosystem conservation in supply chains by utilizing market mechanisms, and products with certification labels based on these systems are being on sale. At present, common certification systems are mainly limited to primary industries such as forestry, fishery and agriculture. If the Life Cycle Assessment (LCA), an established environmental impact assessment method, can be applied to manufactured goods as well, then it would be possible to expand certification systems for them. Furthermore, packaged certification services to conserve ecosystems could be offered in the service industry.

Certification labels on globally distributed products to promote conservation provide traceability that makes society safer. Encouraging certification systems and the distribution of products with certification labels in order to preserve ecosystems in many value-added industries would mean taking the lead in next-generation market mechanisms. An effective way to create new certification systems would be for industry groups and academic societies to take a leadership role and to encourage analytical and investigative projects by experts. Market mechanisms would result in an effective way to foster awareness in the form of participation in conservation throughout society, in addition to the global spread of ecosystem conservation.

(Original Japanese version: published in January, February 2012)

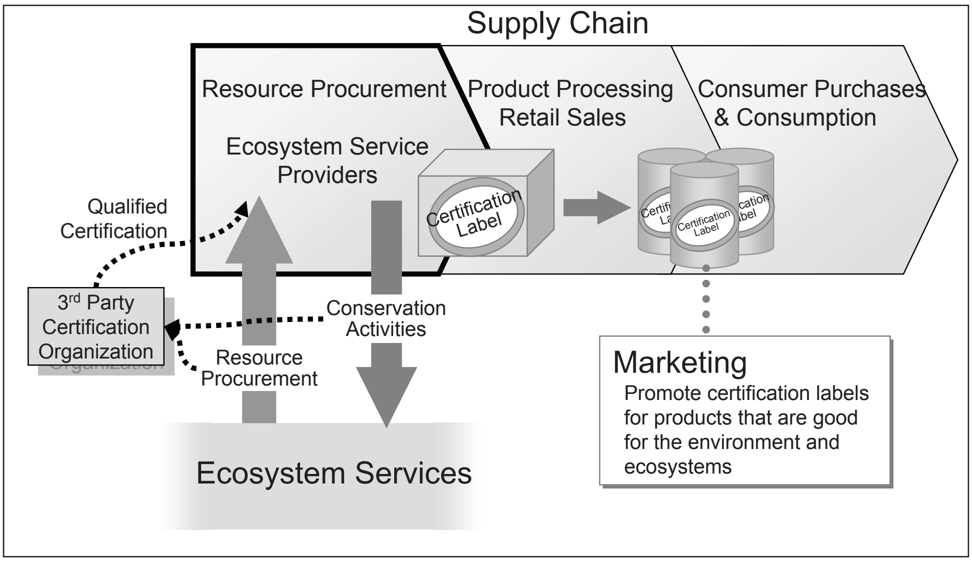

Figure : Market Mechanism-based Ecosystem Conservation Methods

Prepared by the STFC

4 Globalization and the Intensification of Global Competition Seen in the IEEE: What Impact will International Mobility of Research Personnel have on R&D? Symposium Report

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The abovementioned symposium was held at the National Institute of Science and Technology Policy's Science and Technology Foresight Center on September 15, 2011. Following the introduction of circumstances surrounding engineering R&D in Japan and around the world, as well as data on the international mobility of researchers, all participants were invited to participate in discussions held on the two issues.

In order to clarify the circumstances surrounding engineering R&D in Japan and the world in consideration of the international competitiveness of Japan up until now and into the future, premier international society IEEE (the Institute of Electrical and Electronics Engineering, Inc.) was targeted for a variety of analyses, and discussions have been held based on the data received. This symposium was the second of its kind to be held.

According to analysis results on the number of literature, Japan is transitioning in a way all its own. With a leveling off in periodicals, Japan is showing a continuing divergence away from the direction of world research in each field. Despite increased participation in conferences, there has been a downward trend when it comes to the publication of English articles, leading to discussions into the concern that this trend may be due to a decline in the quality level of research. Additionally, although universities currently take on a leading role in the production of literature, the number of fields has remained fixed for a long time, and with the expansion of diversity trending at a snail's pace, concerns have been raised that Japan's engineering R&D might only continue to weaken. On the other hand, with regard to international mobility of researchers, the international movement of researchers in Japan is rare, no matter the field, with researchers tending to stay in Japan and stick to the same organization. Acceptance of foreign researchers in companies and other organizations is also rare, prompting discussion into the causes and concerns of this trend. Generally speaking, subject that were raised as those that are necessary for future study included "ensuring diversity," "the importance of people," "the need for change among Japanese scholarly societies," "network formation," "the provision of meta-information," "the enhancement of information transmission to countries overseas," "utilizing the wisdom of other fields," and "reconsidering Japan's geographical significance."

(Original Japanese version: published in January, February 2012)

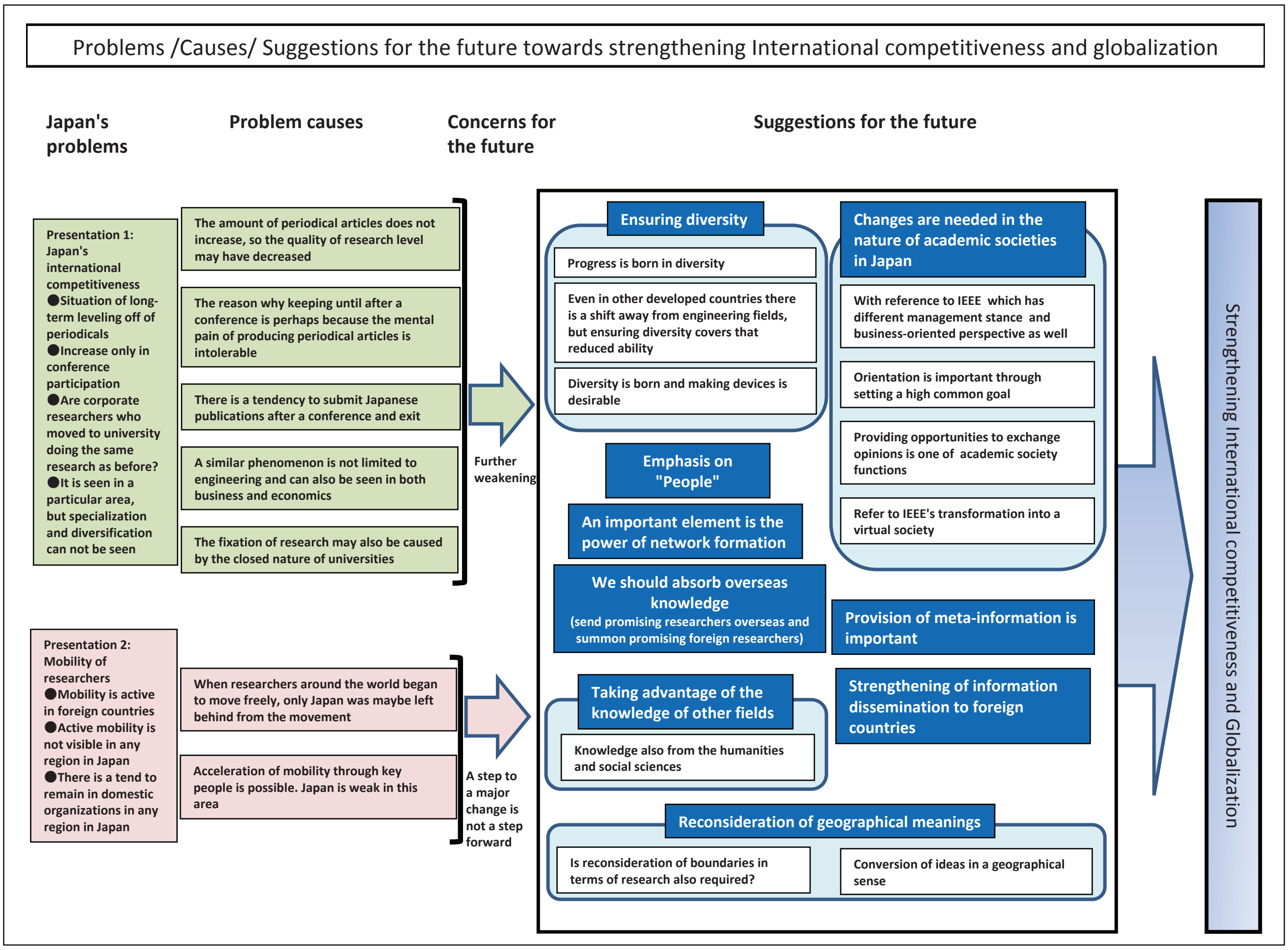

Figure : Problems Causes, Concerns and Suggestions derived from opinions

1

Contribution of Geothermal Energy for Regional Innovation and Earthquake Recovery

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Green Innovation Unit

1 Introduction

After the Great East Japan Earthquake in March 2011, Japan has been promoting various policies like the Strategies to Revitalize Japan[1]. In particular, there has been discussion around realizing a new optimum energy mix, with the aim of strengthening and accelerating green innovation strategies. It is essential that the adoption of renewable energy be more accelerated than ever. The Energy and Environment Council[2] worked with related government ministries and agencies and other organizations to deepen the national debate and drew up a basic energy plan consisting of a new optimum energy mix. The Guideline on Policy Promotion (May 17, 2011, Cabinet Decision) discusses environmental and industrial strategies in line with this plan as well as the Innovative Strategy for Energy and the Environment consisting of green innovation strategies (which support the abovementioned plan and strategies). The guidelines state that the government will, in the short term, respond to restrictions on electricity, foster growth by, for example, creating disaster-resistant energy supply systems (including the construction of Eco-Towns, energy conservation and new energy businesses, the development of distributed energy systems), create a virtuous cycle for expanding capital demands, and implement these initiatives in the disaster-stricken region ahead of other regions. The guidelines also state that the government will, in the medium to long term, strengthen initiatives to create new energy and environmental structures that respond to requests for a safe, stable supply, efficiency, and for the environment[3].

Renewable energy does not become depleted as long as it is used within the range of nature's replenishing power and, in general, it does not cause global warming. The International Energy Agency (IEA) explains in its publication (Renewables Information), "Renewable energy is derived from natural processes that are replenished constantly. In its various forms, it derives directly from the sun, or from heat generated deep within the earth. Included in the definition is electricity and heat generated from solar power, wind power, the ocean, hydropower, biomass, geothermal resources, and biofuels and hydrogen derived from renewable resources". As to solar power generation, a system for purchasing surplus household electricity was launched, and the use of solar power panels for households has been promoted, but improving efficiency is an issue[5]. In addition, the adoption of wind power generation, small-scale hydropower generation[6], and biofuel co-combustion (at thermal power plants)[7] have been promoted in industry in recent years.

This article reviews the current state of geothermal power generation both in Japan and the world and discusses the potential of geothermal heat as an energy source, the contributions the use of heat can make to regional communities, and related policies.

2 Current State and Issues of Geothermal Energy

2-1 Geothermal Resources

Geothermal resources can be defined as heat generated within the Earth that can be used as energy. Geothermal energy can be used both to generate power and as a direct heat source, and it is expected to reduce fossil fuel consumption and greenhouse gases[8].

Temperatures within the Earth increase with depth below the surface, and the rate of the temperature increase is called the geothermal gradient. The average geothermal gradient in Japan is about 30°C/km[8] (the global average is about 20°C/km). If depth is not an issue, underground heat resources exist everywhere. However, for heat resource usage to be economical, it is desirable to find resources at as shallow a depth as possible. As long as one uses heat moderately, the Earth will continuously replenish it, and so it is a sustainable and renewable source of energy.

As Figure 1 shows types of geothermal resources. The geothermal resources can be divided into two types depending on how the heat is replenished: 1) convection-dominated geothermal resources (heat from deep underground is transferred to groundwater and moves up through circulating water) and 2) hot dry-rock geothermal resources (there is no circulating water and the rock conducts heat). When people talk about geothermal resources, they usually mean the former. This form is easier to use, since heat is obtained as hot water or vapor, and like hot springs, hot water sometimes pours out naturally.

Figure 2 shows underground model of Geothermal Resouce. Hot water and vapor (used for power generation) are heated by geothermal heat in a groundwater reservoir (confined and pressurized under a shielding layer), which often lies 1,000 to 2,000 meters underground. Heated groundwater is brought up through a production well as pressurized vapor or hot water. Recently, it has become clear that the source of the water (hot water for either power generation or hot spring) is rainwater from the surrounding area. After it is used for geothermal generation, cooled water is usually returned underground through an injection well to maintain the underground water balance and prevent the surrounding environment from being affected by impurities from underground[10].

Japan is one of the countries that have abundant geothermal resources. Figure 3 shows geothermal power generation resources and installed power generation capacity. Japan's hot water resources (over 150°C) alone amount to 23,470 MW when converted into power output (which could supply hot water at 150°C for thirty years)[11]. Japan has the world's third largest geothermal resources (after the United States

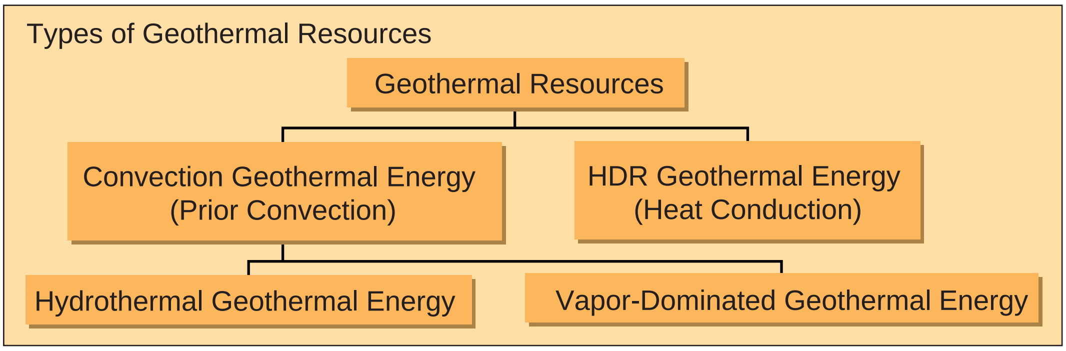


Figure 1 : Type of Geothermal Resources

Source: Reference[9]

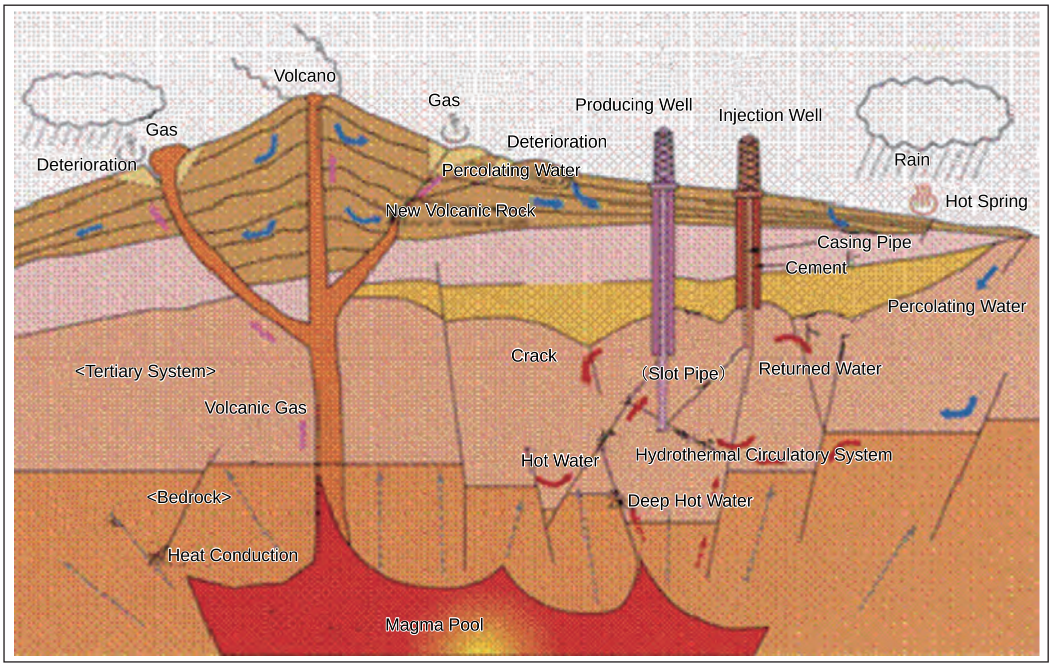


Figure 2 : Underground Model of a Geothermal Resource(Onuma-Sumikawa Geothermal System)

Source: Reference[10]

and Indonesia), and it still has abundant untapped geothermal resources.

Geothermal resources can be used not only for geothermal power generation but also as a direct heat source. Figure 4 shows how geothermal energy is used. Hot water and vapor usually come out through a well using their own pressures, and, generally speaking, it is easy to provide energy even during external power outages and other emergencies, depending on the system structure.

The use of underground heat requires the technology to use soil or water underground (at 0-100 meters deep) as a heat source for a heat pump. The topic was previously covered in Science & Technology Trends (No. 90, September 2008). The underground temperature is roughly constant throughout the year. It is lower than the air temperature in summer and higher in winter. Therefore, if waste heat is put underground in summer, and heat is brought out as a thermal source for a heat pump in winter, one can run an air conditioner, heater, snow-melting system, or water heater using less power than if one were using the air as a thermal source[12].

2-2 Geothermal Power Generation

2-2-1 Comparison of Other Renewable Energy

Compared with other renewable energy, geothermal power generation has the following major characteristics.

- Compared with solar power and wind power generation, geothermal generation is reliable in terms of supply. A stable power supply is attainable with no need to set up a back-up power source and secondary battery. In addition, operating ratios are higher than solar power and wind power generation, and so as shown in Figure 5, geothermal generation can annually produce power energy several times higher than solar and wind power generation. Facility utilization rates are also high, and the power generation unit price is about one fifth to one third of the unit price of solar power[15].
- Heat is a byproduct and can be used for various purposes.
- The emissions rate of CO_2 over the lifecycle of the facility is about one quarter to one half of the CO_2 emissions generated from solar power and wind power generation as shown in Figure 6.

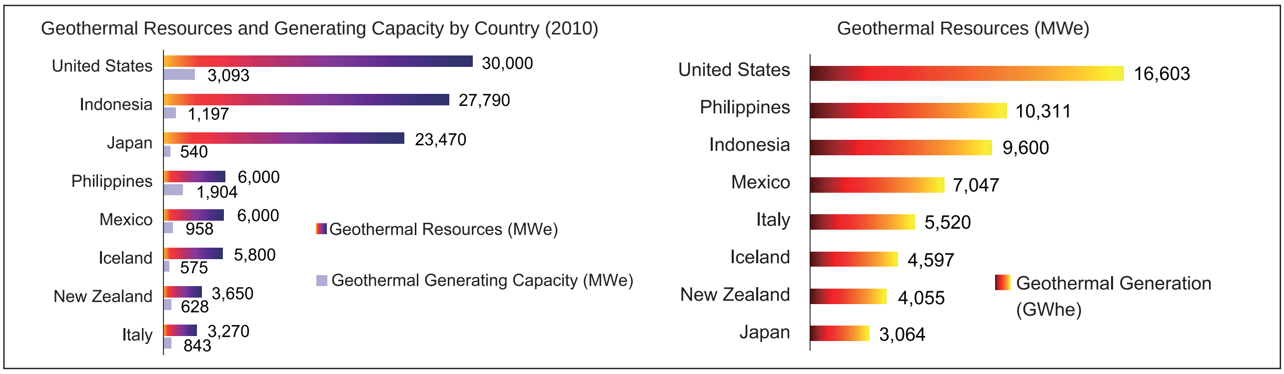


Figure 3 : Geothermal Resources, Installed Power Generation Capacity, and Geothermal Power Generation around the World

Source: Prepared by STFC based on Reference[13,14]

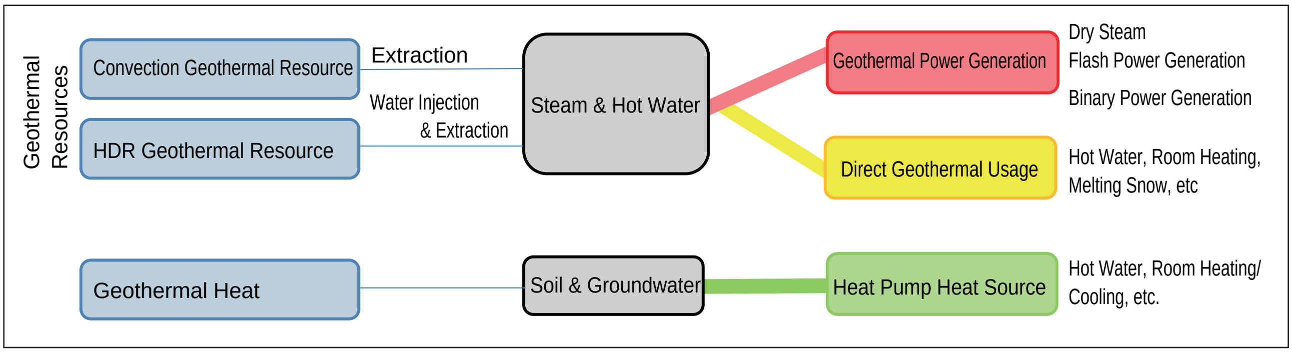
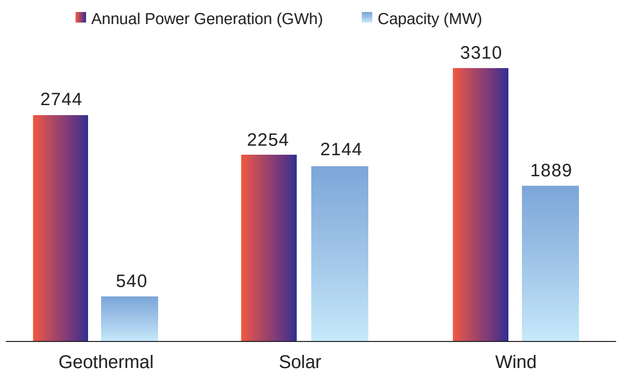


Figure 4 : Usage of Geothermal Resources

Prepared by STFC.

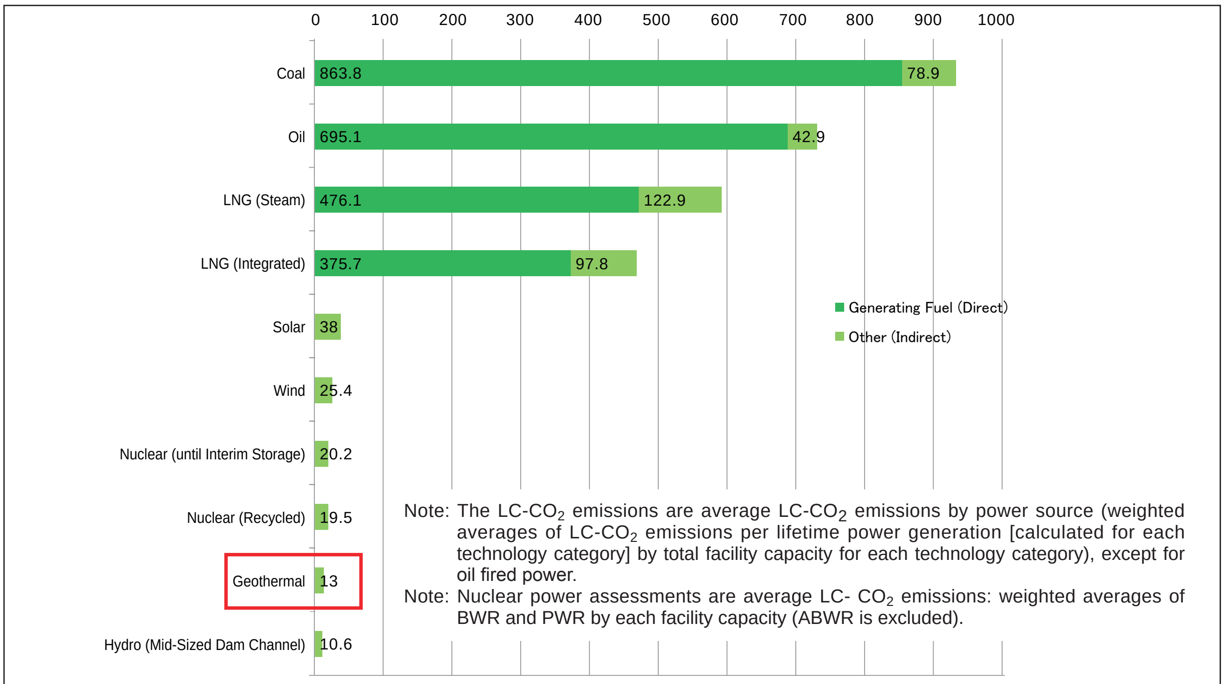


Generating Method	Cost (JPY/kWh)	Utilization (%)
Hydro	8.2~13.3	45
Oil	10.0~17.3	30~80
LNG	5.8~7.1	60~80
Coal	5.0~6.5	70~80
Nuclear	4.8~6.2	70~85
Solar	46	12
Wind	10~14	20
Geothermal	7.8~18.3	70

Basis for Annual Power Generation
- Geothermal: FY2008 results data (Reference [15])
- Solar: Calculated according to assumed facility utilization of 12% based on 2,144 MW currently installed as of FY2008 (Reference [16])
  Annual Power Generation = 2,144 MX x 24 hrs x 365 x 0.12 x 0.001 (GWh / MWh)
- Wind: Calculated according to assumed facility utilization of 20% based on 1,889 MW currently installed as of FY2008 (Reference [16])
  Annual Power Generation = 1,889 MX x 24 hrs x 365 x 0.2 x 0.001 (GWh / MWh)

Figure 5 : Comparisons of Annual Power Generation, Facility Capacity, Power Generation Unit Price, and Facility Utilization Rate (Fiscal 2008)

The graph was prepared by STFC. The power generation prices and facility utilization rates are based on Reference[15].
*Nuclear power generation prices are being reassessed by the Japan Atomic Energy Commission.



Note: The LC-CO_2 emissions are average LC-CO_2 emissions by power source (weighted averages of LC-CO_2 emissions per lifetime power generation [calculated for each technology category] by total facility capacity for each technology category), except for oil fired power.
Note: Nuclear power assessments are average LC- CO_2 emissions: weighted averages of BWR and PWR by each facility capacity (ABWR is excluded).

Figure 6 : CO_2 Emission over the Lifecycle of a Facility by Type of Power Generation (Unit: g-CO_2/transmission end kWh)

Source: Reference[17]

2-2-2 Issues Surrounding Geothermal Resource Development in Japan

In Japan, the capacity of geothermal power stations increased by 314MW between 1990 and 1996, accounting for more than half of the current capacity, 540MW. This trend coincides with efforts to develop geothermal resource exploration technology and hot water/vapor handling technology based on oil development and mine technology as well as to cultivate human resources after the launch of the "Sunshine Project" in 1974. However, since the launch of the Hachijo-jima geothermal power plant in 1999, no plants have been established except for expanded small-scale binary power generation, discussed below[18]. This is in contrast to trends in the United States, the Philippines, Indonesia, Italy, and elsewhere, where geothermal power generation is rapidly becoming popular.

Some of the reasons that Japan's geothermal power generation is not increasing in contrast to other renewable energy or other countries are as follows:

1) A resource survey takes a substantial amount of time and, depending on the result, there is risk of giving up on commercialization in the middle of the process.
2) Many places appropriate for geothermal power generation are located in natural parks, and it is difficult to develop facilities under the current Natural Parks Law.
3) Some point out that development will affect hot springs.
4) It takes at least three years to finish environmental impact assessment procedures.
5) A secondary factor for each of the abovementioned causes is that the lead time between the launch of a development process and the beginning of actual power generation operation is more than ten years. As such, it takes a long time to recover investments, and business incentives are low.
6) Compared with other renewable energy, the government's assistance for initial investments is scarce.

In particular, items 2) to 4) are causes for concern in Japan. The Natural Parks Law regulates power generation facilities in national parks in order to protect the natural environment and landscape. National parks and hot spring areas have abundant hot water resources that can be used for geothermal power generation, but due to regulation, their development has not been promoted.

In addition, due to the budget screening in May 2010 under the Democratic Party of Japan administration, it was determined that the geothermal development promotion survey project and the geothermal power generation development project would be reviewed on the presumption that the projects may be abolished[19].

Of the geothermal development costs, excavation accounts for a substantial fraction, which has to be resolved. The key to geothermal commercialization depends on whether a sufficient supply of hot water can be secured, and there is a high risk of excavating unsuitable sites before finding a hydrothermal vein that will support a stable business. If many excavations are required, the investment for a geothermal business becomes substantial. It costs between 300 million to 400 million yen to excavate a well down to about 2,000 meters, and the risks for a private company are huge. This is one of the major reasons why geothermal commercialization has not been promoted.

The government provides initial investment support to new energy, including geothermal energy. However, the support differs considerably depending on power generation sources. The new energy introduction acceleration support project in fiscal 2011[20] sets upper limits: solar power generation may receive either up to one third of the total cost or 250,000 yen/kW, whichever is lower; wind power may, after an individual consultation, receive up to 1.5 billion yen if there is adequate cause; natural gas cogeneration and microgrid systems may receive up to 500 million yen. In contrast, geothermal power may receive up to one half of the cost of a survey and excavation project and one fifth of the establishment cost of a geothermal power generation facility[21]. This means, for example, that only up to 500 million yen may be subsidized for an excavation survey that costs about one billion yen. As discussed below, only 24 million yen may be subsidized for establishing the electric power system required for a binary power generation system 50kW (transmission end), grid connection, etc. that costs about 120 million yen[22]. As discussed in item 6), geothermal power generation is at a disadvantage when it comes to receiving government assistance.

Due to these factors, not much attention has been given to geothermal energy compared to other renewable energy. Geothermal energy has its own unique issues, but most of the issues are expected to be resolved to some extent.

3 Current State of Geothermal Energy Use in Japan

3-1 Geothermal Energy Use for Power Generation

The output (i.e., facility capacity) of individual commercial geothermal power generators currently installed in Japan is between few l MW and 112 MW. For example, some hotels and other private facilities have a capacity of 100kW. Power for commercial uses generated by geothermal energy is transmitted to a distant point of demand, and so, like thermal power and hydropower plants, it requires a concentrated power source. Roughly speaking, geothermal power generation for commercial uses needs power output equal to a large-scale wind power generator or even larger, like a small and medium-scale water power generation facility. Current typical geothermal power generation depressurizes (or flashes) extracted vapor or hot water (part of which turns into vapor), sends

Table 1 : Current State of Geothermal Power Generation (as of November 2010)

Pref.	Plant	Location	Steam Supply	Utility	Use	Rated Output	Start Year	Direct Geothermal Use
Hokkaido	Mori	Mori, Kameda	HEPCO	HEPCO	General	50MW	1982	69 greenhouses
Akita	Sumikawa	Kazuno	Mitsubishi Materials	Tohoku Electric Power	General	50MW	1995	
	Onuma	Kazuno	Mitsubishi Materials	Mitsubishi Materials	General	9.5MW	1974	
	Uenotai	Yuzuwa	Akita Geothermal Energy	Tohoku Electric Power	General	28.8MW	1994	Kurikoma Foods (food processing), Minase Heated Pool, Akinomiya Heated Pool
Iwate	Matsukawa	Hachimantai	Tohoku Hydropower & Geothermal	Tohoku Electric Power	General	23.5MW	1966	Hachimantai Geothermal Steam Dyeing Workshop, room and water heating for nearly 700 hotels, inns, guesthouses, pensions, resort houses, shops and hot spring facilities, 95 greenhouses
	Kakkonda No. 1	Shizukuishi, Iwate	Tohoku Hydropower & Geothermal	Tohoku Electric Power	General	50MW	1978	Iwate Prefecture Indoor Heated Pool (alt. name: Hotswim)
	Kakkonda No. 2	Shizukuishi, Iwate	Tohoku Hydropower & Geothermal	Tohoku Electric Power	General	30MW	1996	
Miyagi	Onikobe	Osaki	J-Power	J-Power	General	15MW	1975	Oraga Tropical Garden
Fukushima	Yanadu-Nishiyama	Yanaizuma, Kawanuma	Okuaizu Geothermal	Tohoku Electric Power	General	65MW	1995	
Tokyo	Hachijojima	Hachijo	TEPCO	TEPCO	General	3.3MW	1999	Greenhouses, mixed bathing facilities
Oita	Suginoi Hotel	Beppu	Suginoi Hotel	Suginoi Hotel	Private	1.9MW	1981	Hot springs, room heating, water heating, cooking
	Otake	Kokonoe, Kusu	Kyuden	Kyuden	General	12.5MW	1967	
	Hacchobaru No. 1	Kokonoe, Kusu	Kyuden	Kyuden	General	55MW	1977	
	Hacchobaru No. 2	Kokonoe, Kusu	Kyuden	Kyuden	General	55MW	1990	
	Hacchobaru Binary	Kokonoe, Kusu	Kyuden	Kyuden	General	2MW	2006	
	Takiue	Kokonoe, Kusu	Idemitsu Oita Geothermal	Kyuden	General	27.5MW	1996	Water heating for 40 private homes
	Kokonoe	Kokonoe, Kusu	Kuju Kanko Hotel	Kuju Kanko Hotel	Private	0.99MW	1998	Hot springs, room heating, water heating
Kagoshima	Ogiri	Kirishima	Nittetsu Kagoshima Geothermal	Kyuden	General	30MW	1996	
	Kirishima Int'l Hotel	Kirishima	Daiwabo Kanko Kirishima Int'l Hotel	Daiwabo Kanko Kirishima Int'l Hotel	Private	0.1MW	1984	Hot springs, room heating
	Yamakawa	Kirishima	Kyuden	Kyuden	General	30MW	1995	
8 Pref.	*17 Places*		*13 Companies*	*9 Companies*		*540.09MW*		

Prepared by STFC based on Reference[23]

steam into a steam turbine, and the rotating turbine generates power. Therefore, even when the amount of hot water is the same, the higher the temperature of the hot water is, the higher the power output becomes, leading to higher economic efficiency. As such, it is desirable to establish a facility at a location with high temperature hot water.

Table 1 shows the current state of geothermal power generation in Japan. Currently, facilities are located in eight prefectures, and many of them are situated along the volcanic belts in Hokkaido, the Tohoku for, and the Kyushu region. The facilities provide not only electricity but also supply heat for contributing to regional businesses.

3-1-1 Dry Steam and Flash Steam Power Generation

If spew from a production well is vapor containing very little hot water, only simple moisture removal is required before transferring steam into a steam turbine to generate power. This method is called dry steam power generation. The Matsukawa geothermal power plant, Japan's first geothermal power plant, has been using this method to generate power since 1966. If a well produces mostly hot water and not so much vapor, a steam separator is used to separate (or flash) steam, which goes into a steam turbine for power generation. This method is called flash steam power generation (Figure 7). After the steam is separated, if the pressure of the remaining hot water is high enough, a second separator can be installed to depressurize the hot

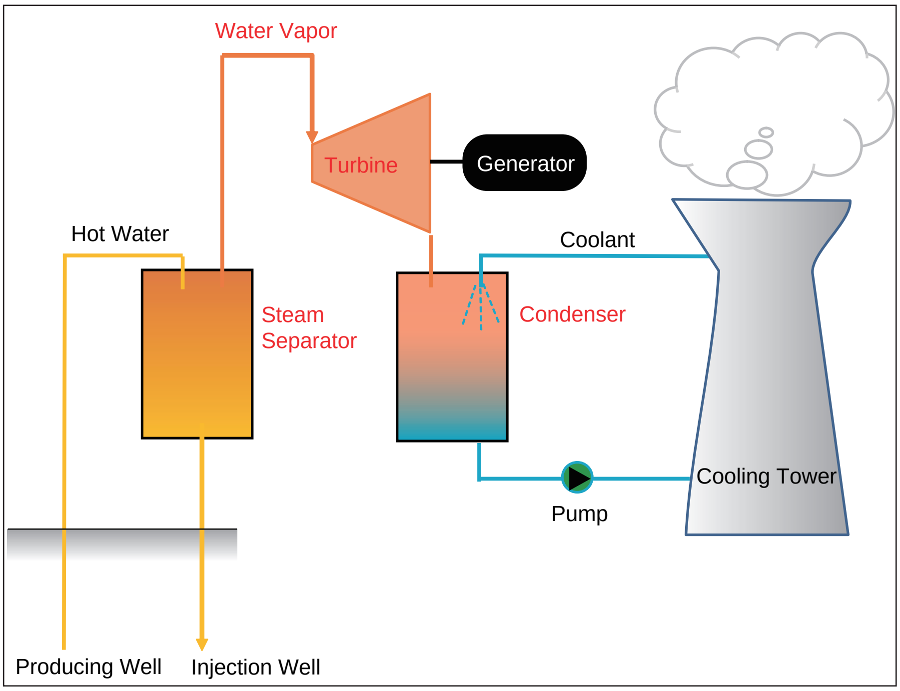


Figure 7 : Dry Steam/Flash Steam Power Generation

Prepared by the STFC

water to create more steam, which is then put into the mid-section of the turbine in order to improve power output and use geothermal energy effectively. This is called a double flash cycle and used at the Mori and Hacchobaru geothermal power plants (Table 1).

The largest output from an individual dry steam and flash steam power generator is 140MW (New Zealand). Dry steam and flash steam power generation is used as concentrated power sources and is the mainstream of geothermal power generation. These methods are mostly suitable for locations producing hot water at temperatures greater than 200°C. Three Japanese makers (Mitsubishi Heavy Industries, Toshiba, and Fuji Electric) account for 70% of the world's share of geothermal turbines for large-scale power generation. Geothermal turbines and generators are exposed to a more severe environment compared to thermal power generation because various underground materials are sent as-is to turbines. Thermal turbines used to require biennial maintenance, but Japanese makers created turbines that are more corrosion-resistant with coated rotors and stators. In addition, by installing equipment to capture moisture (water droplets) and drain it out of turbines and making other improvements, thermal turbines are now of a higher quality and can be used continuously and stably for six years without problems. These improvements are the reason for Japan's expanded market share.

3-1-2 Binary Power Generation

The steam is usually used to rotate turbines, but with binary (cycle) power generation other substances with lower boiling points than water (e.g., hydrocarbon) are heated and vaporized, and the pressurized steam is used to operate a power generation system. This method can use heat sources at temperatures lower than 150–200°C (which cannot be used with a water/steam-based system) as shown in Figure 8.

In recent years, this method has become increasingly popular. Ormat in Israel holds the world's top share in this method. Kyushu Electric Power's Hacchobaru geothermal power plant (110MW), they have been they using with a 2MW binary power generation system since 2006 that using an existing production well where the power output had declined. Normal pentane (boiling point: 36°C) is used to operate the turbine. In addition, the Kalina cycle (a kind of binary power generation) uses a solution of water and ammonia and can generate power using heat resources at even lower temperatures (less than 100°C).

Binary power generation was recognized as a new energy source by the RPS law[NOTE1]. It does

[NOTE 1] Renewables Portfolio Standard is a system that requires electric power suppliers to use a certain proportion of electricity generated from new energy, depending on the amount of energy they distribute each year, in order to promote new energy.

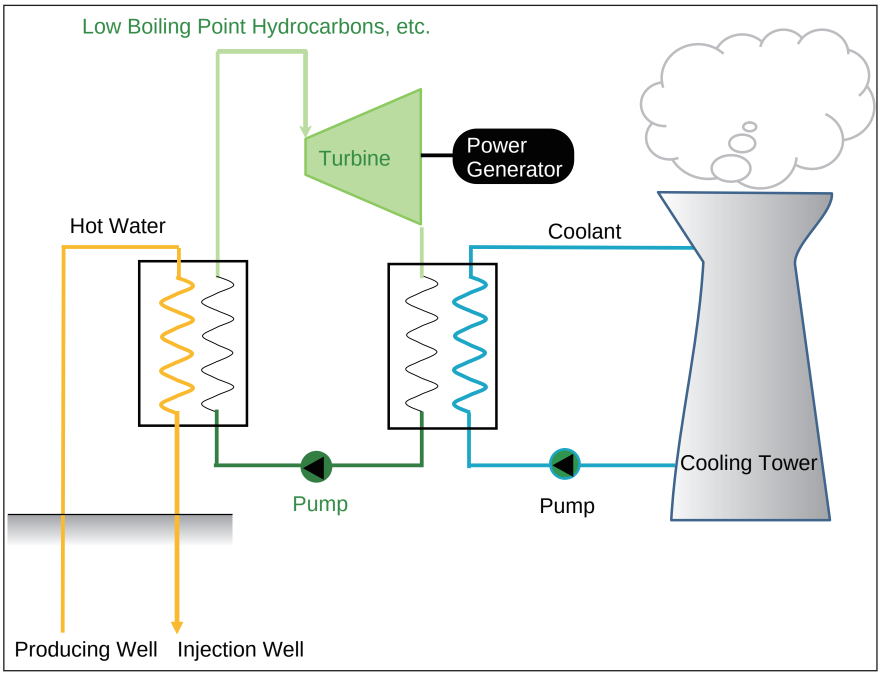


Figure 8 : Binary Power Generation

Prepared by STFC

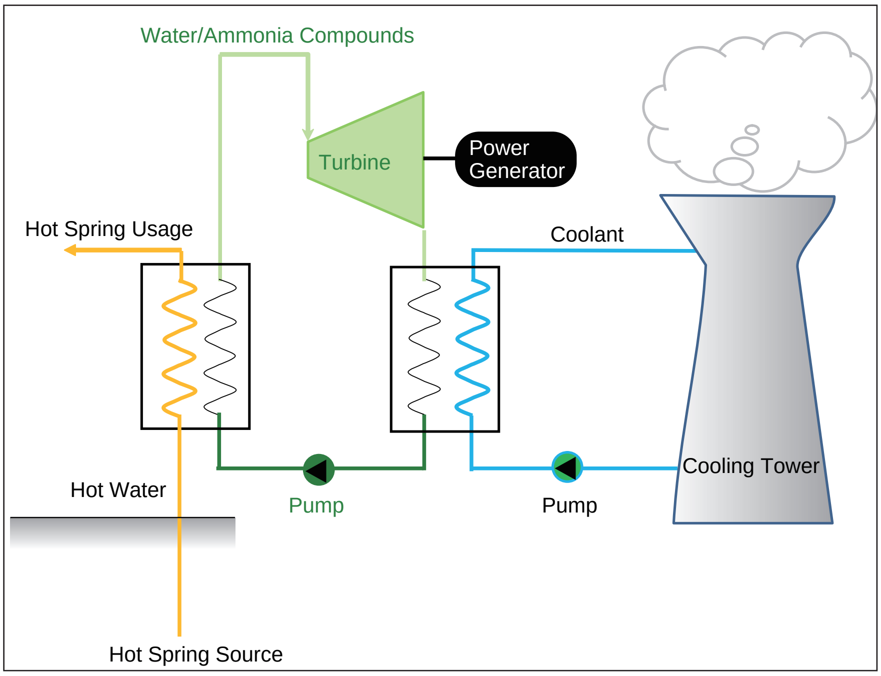


Figure 9 : Hot-Spring Power Generation

Prepared by STFC

not require high temperature heat sources like flash steam power generation, and compared to the flash steam system, many locations are suitable for the establishment of a binary power plant. Therefore, the number of binary power plants is expected to increase in Japan as well as world.

3-1-3 Hot-Spring Power Generation

An estimate indicates that the Kalina cycle system could generate approximately 722MW of power using unused heat released from existing hot springs while maintaining an appropriate temperature for bathing[24]. The system is a kind of binary power generation discussed above and is commonly called "hot-spring power generation." Characteristically, there is no need to excavate a new well, and so it can start generating power easily. Hot-spring power generation is expected additional power generation to existed Geothermal energy capacity as shown in Figure 9.

3-1-4 Enhanced Geothermal System

In Figure 10, the enhanced geothermal system (EGS)

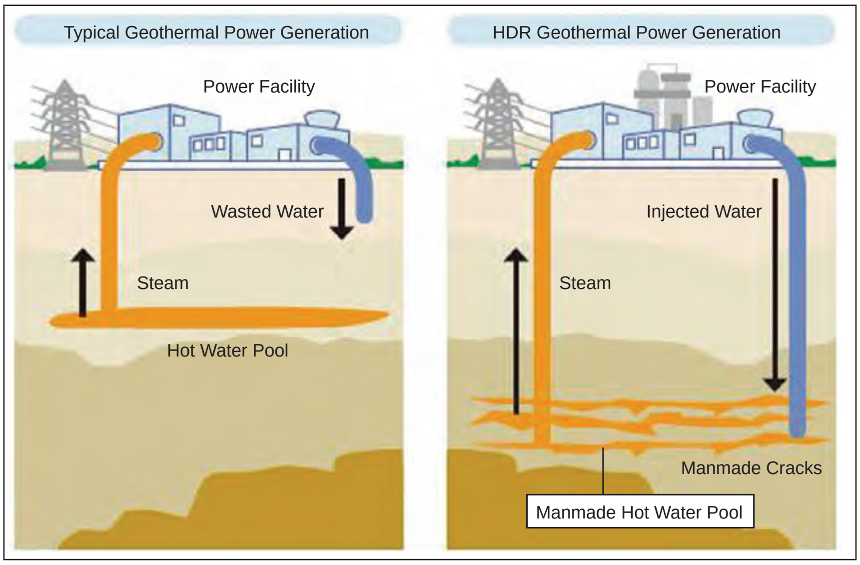


Figure 10 : Enhanced Geothermal System

Source: Reference[48]

generates power by injecting water into underground hot dry rocks, artificially creating steam and hot water, and retrieving them to turn a turbine. The EGS is a next-generation technology for places where natural vapor or hot water cannot be attained. The important technologies for this system concern the artificial creation of cracks so that water can pass through underground hot dry rocks and the injection of high-pressure water underground to collect hot water or vapor.

The Central Research Institute of Electric Power Industry (CRIEPI) and the NEDO conducted hot and dry-rock thermal resource recovery tests in Ogachi, Akita prefecture and Hijiori, Yamagata prefecture, respectively. In the latter case, a hot water recovery and circulation test was conducted for about two years, and a 50kW power generation test was conducted for about three months. The tests were completed in fiscal 2002, and no continuous tests have been conducted since[25].

3-2 Usage as Heat

More than half the energy for households is used to generate heat for, for example, making hot water or heated air. In Figure 11, there is also a variety of heat energy uses in industry.

Unlike other renewable energy, not only can geothermal energy generate electricity but it can also provide a substantial amount of heat energy to communities. In other words, by using heat energy, we can expect to save energy resources and prevent global warming.

The higher the temperature of a geothermal resource, the greater the variety of uses it has. Thermal efficient cascading use of hot water is possible since after high temperature water is used, the water can be reused for other purposes even after the temperature goes down. In addition, hot water generated in the steam separation process for flash steam power generation can be used as a heat resource before the water goes into an injection well by having it exchange heat with clean tap water to create warm water. Thermodynamically, less than 10% of hot water at a temperature lower than 120°C can be converted to electricity, but if it is used directly as heat, all of the water's heat energy can be utilized.

In recent years, the use of geothermal heat for air conditioning/heating systems has been rapidly becoming popular around the world, and it is already in practical use in many places in Japan. In this case, one does not need to excavate a well to collect hot water, and heat can be used by a simple construction method like putting a heat exchanger pile in the ground. For example, Tokyo Sky Tree and other large-scale commercial facilities have recently adopted geothermal heating systems. The coefficient of performance (COP) at Tokyo Sky Tree is expected to exceed 1.3, the highest district heating and cooling (DHC) level in Japan[26].

Unlike hot water use, geothermal heat use is not completely CO_2 free, but the energy-saving effect is great. Advantages for the widespread use of geothermal heat are the mitigation of the urban heat island effect, the reduction of electricity consumption and CO_2 emissions by reducing fire-powered heating in cold regions, and smoothing of

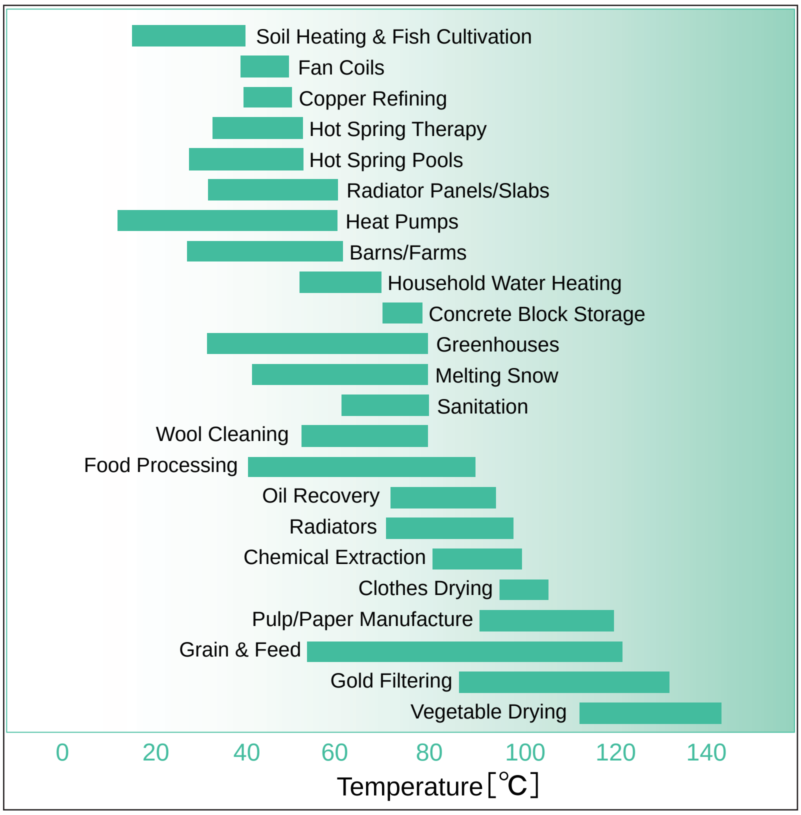


Figure 11 : Heat Energy Use by Temperature

Source: Reference[8]

electricity consumption by reducing peak electricity in midsummer and using nighttime power.

Thus, geothermal heat can be used to create an energy system as a power generating source, depending on regional circumstances, and also as heat, which is not affected by climate conditions. Geothermal heat also hardly doesn't depends on fossil fuels.

4 Geothermal Energy Use in the World

In contrast to Japan, geothermal power generation grew rapidly by about 30% in the decade between 1995 and 2005. In particular, the growth in the United States, Iceland, and Indonesia is notable. Especially, the federal and state governments support renewable energy in United States.

The use of geothermal heat pumps has become popular in the United States, Sweden, and, recently, China.

4-1 United States

One of the guiding principles for energy and environmental policy in the United States that called "Investing in the clean energy jobs of the future." The government aims to create 17,000 jobs by providing 2.3 billion dollars in tax credits for the clean energy manufacturing sector[27].

Currently, the Department of Energy (DOE) and other organizations are actively investing in geothermal energy. The American Recovery and Reinvestment (ARR) Act of 2009 provided 350 million dollars for verifying developing geothermal power generation and 50 million dollars for geothermal heat pumps[28]. Specifically, a National Geothermal Data System (NGDS) is aimed at reducing the risk of failure for geothermal developers by providing comprehensive information, including geothermal resource data and assessment, technological information, successes and failures in geothermal research, and policies. In addition, the Office of Electricity Delivery & Energy Reliability of the DOE has been working with other organizations on the electric grid to allow geothermal energy resources to reach distant markets.

The Geothermal Technologies Program (GTP), an industry-government-academia program launched in 2008, aims to popularize geothermal power generation and reduce power generation costs by 2020 or 2030. The GTP conducts activities organized around the five areas shown below[29]. The National Renewable

Energy Lab (NREL) estimates that enhanced geothermal power generation has a potential of 16,000 GW in the United States, and so the development of enhanced geothermal systems technology is particularly emphasized.

• Enhanced geothermal systems technology
• Hydrothermal power
• Low-temperature resources
• Strategic planning, systems analysis and geothermal data
• Technology validation

In 2008, for example, Google invested 10 million dollars in ventures including: AltaRock Energy, which works on Engineered Geothermal Systems (EGS) (6.25 million dollars); Potter Drilling (4 million dollars); and the Southern Methodist University Geothermal Laboratory, which works on the mapping of geothermal energy resources in North America (489,521 dollars). Such research and development has been ongoing[30].

4-2 Indonesia

Indonesia has huge geothermal potential some as Japan. Unfortunately, the usage rate for geothermal power generation used to be about 4.5%, making up less than 3% of Indonesia's total resources. However, in 2003, the Indonesian government adopted a Geothermal Law and drew up a geothermal power generation roadmap. According to the roadmap, the government is planning to expand by 2025 the capacity of geothermal power facilities to about 1 GW (5% of primary energy), which will be about eight times greater than the current level. To achieve the plan, it is essential to promote Independent Power Producers (IPPs)[NOTE2], which raise private funding, and a total of 20 billion yen (including 10 billion yen of credit) will be funded for exploratory drilling for geothermal energy. JICA, JBIC, consulting companies, and trading firms from Japan are planning to provide financial and technological assistance to develop geothermal energy[31]. Indonesia does not have a natural park law like Japan, and geothermal development is expected to proceed more easily. It is also interesting that Indonesia is trying to develop geothermal energy even though the country has abundant fossil resources such as oil, natural gas, and coal.

4-3 Iceland

The population of Iceland is about 320,000. In the 1930s, the capital Reykjavik was suffering from smog from coal power generation and began shifting to oil. However, the 1970s oil crisis forced Iceland to reexamine this policy, and the use of geothermal energy has become more popular. Geothermal energy was developed primarily for community air heating, and now, 90% of the population has been using on geothermal heat for air heating. Geothermal energy is used primarily as a heat source, with excess energy being used for power generation. Iceland has abundant renewable energy such as hydro and geothermal energy. In 2009, renewable energy accounted for 85% of primary energy. In addition, 100% of electricity is supplied by renewable energy (about 30% by geothermal and 70% by hydro energy)[32]. Notably, Iceland did not have many industries other than fishing, but, taking advantage of electricity generated from 100% renewable energy, Iceland attracted multi-national aluminum smelting plants, which consume 70% of the country's electricity. Iceland's clean electricity is then exported to the world as a form of aluminum. In addition, the Svartsengi geothermal power station uses geothermal seawater (taken up for power generation) to operate Blue Lagoon, the world's largest open-air hot spring resort for the public.

4-4 Germany

Germany is enthusiastic about using renewable energy and has actively been promoting the use of geothermal energy. The government is expected to increase geothermal power generation capacity by 2020 to about 280 MW, 40 times higher than the current level. This equals to 1.8 TWh/year of power. A total of 8.2 TWh of heat is also expected to be supplied by deep geothermal energy by 2020 (3.4 TWh from geothermal power stations and 4.8 TWh from heat from geothermal facilities that do not generate power and only provide heat). In addition, 850 MW of power generation capacity is expected to be added by 2030[33].

Currently, there are three geothermal power

[NOTE 2] Independent Power Producer (IPP) is also called a "wholesale power provider" in Japan. The 1995 revision of the Electricity Business Act allowed general businesses to supply wholesale power to electric power companies.

stations and 167 heat supply facilities (which use deep geothermal energy and do not generate power). For example, hot-water-based binary power generation is in operation in Landau and Unterhaching (south of Munich). They each recover hot water at around 120°C from a depth of 3.3 to 3.4 km deep. Germany does not have volcanic hydrothermal systems. But despite this disadvantage compared to geothermal power plants abroad, geothermal power generation is in operation, showing the country's serious willingness to develop geothermal energy[34]. In 1999, a comprehensive geothermal energy facility was established in Erding, north of Munich. This facility obtains 80t/h of warm water at 65°C from a depth of 2,300 meters, and the water is then heated up to about 100°C through a heat exchanger and heat pump. The hot water is used for community air heating and industries, and groundwater cooled via the heat exchanger and heat pump is used for an artificial hot spring and drinking. As such, all the heat and water resources obtained from underground are effectively used[35].

To promote geothermal power generation projects, Germany created policies that give preferential treatment to geothermal projects and reduce related risks. The Renewable Energy Law adopted in January 2009 raised compensation prices for purchasing geothermal power and also adopted a special bonus system. As such, the fixed-rate purchasing system and other systems have been effective. For example, a new geothermal power station (up to 10 MW) established in 2009 received a fixed purchasing rate of 16 euro cents/kWh compared to 14 euro cents before the revision, and until 2015, 4 euro cents will be added as a bonus. In addition, if the station provides heat, 3 euro cents are added. However, the fixed purchasing rate will be reduced every year by 1 euro cent per year. Therefore, a power provider who establishes a facility sooner receives more funding, and it is profitable to excavate a depth of more than 3 kilometers. In addition, the Renewable Energies Heat Law adopted in January 2009 requires new buildings to use renewable heat, which has been promoting the use of geothermal energy[33].

The Federal Environment Ministry made 60 million euros available in financing for deep geothermal drilling projects, and this credit program reduces the risks associated with drilling in particular. The KfW Bank Group provides loans for deep underground drilling through commercial banks, and the upper limit is 80% of all the costs necessary for drilling. If no hot water reservoir is found, the investor will not have to pay the remaining amounts once the project is considered a failure[36]. The government also continues to provide grant funding for research and development and tries to reduce technological and geological risks. In this way, Germany has been active in making national policy to develop geothermal energy.

4-5 Australia

Australia is also promoting renewable energy policy and is planning to invest at least 35 billion Australian dollars by 2020. Australia is expected to accelerate the use of renewable energy through the current tax credit system for electricity prices and the federal government's Small-scale Renewable Energy Scheme (SRES).

In 2010, Geodynamics, Ltd. began constructing a large-scale EGS plant. More than 40 venture companies are developing geothermal power generation in the Cooper Basin. Australia does not have volcanoes, and so, to obtain vapor and hot water, the wells must go down to a depth of over 4,000 meters, twice as deep as ordinary wells. Many companies and individuals have already invested in geothermal power generation. One of the reasons why Australia has been increasingly investing in renewable energy even though it has abundant energy resources is that it aims to actively reduce greenhouse gases[37].

5 Expanding the Use of Geothermal Energy in Japan

5-1 Geothermal Power Generation Potential in Japan

Japan's geothermal power generation has not been growing, in contrast to other renewable energy in Japan or geothermal power generation in other countries. As discussed in Chapter 2, factors include the lengthy amount of time it takes to conduct a site survey and construct a large-scale geothermal power station, and the fact that power stations cannot be built in national parks. On the other hand, we have seen progress in small-scale geothermal technologies and excavation technologies such as for binary power generation, which can help solve Japan's unique issues. NEDO created a geothermal resources map, and the risks that surround geothermal development have decreased.

In line with the progress in binary power generation technologies, the National Institute of Advanced Industrial Science and Technology (AIST) and other organizations have been investigating on distribution data for geothermal resources at temperatures lower than 150°C, which were not included in earlier surveys. For example, the Ministry of Environment considers geothermal resources between 53°C and 120°C to be suitable for Kalina cycle power generation, and as shown in Figure 12, these resources exist in places that are far from natural parks, for example, in Tokyo suburbs. Considering that hot water between 53°C and 120°C can be used for Kalina cycle power generation and hot water between 120°C and 150°C can be used for other binary power generation systems, the ministry calculated power output and estimated that the total national reserve of geothermal resources between 53°C and 150°C is approximately 9.6 GW[38]. This is different from the amount of resources (23,470 MW of power output) discussed in Chapter 2.

As mentioned earlier, most hot water resources over 150°C are located in national parks and are therefore problematic to use. However, due to the development of directional drilling, a new technology that excavates wells at an angle beginning outside a regulated natural park and extending directly underneath the park to obtain hot water, it is hoped that geothermal resources under regulated areas will be used at power generation facilities constructed mostly outside the areas. The ministry says that the geothermal development potential for hot water resources over 150°C will increase by almost three times from 2.2 GW (without national parks) to 6.4 GW (with national parks) because of the directional drilling technology.

5-2 Potential of Contribution for Regional Innovation

5-2-1 Creating a Low-carbon Society by Supplying Heat to Communities

A unique characteristic of geothermal energy is that, unlike other renewable energy, not only can it generate power but it can also supply a substantial amount of renewable heat to communities. As shown in Figure 11, there is demand for heat at a variety of temperatures, mainly for light industry, agriculture, and household use, and mostly fossil fuels such as heavy oil, kerosene, and gas are used to generate heat. More than 50% of household energy is consumed to generate heat for air heating and hot

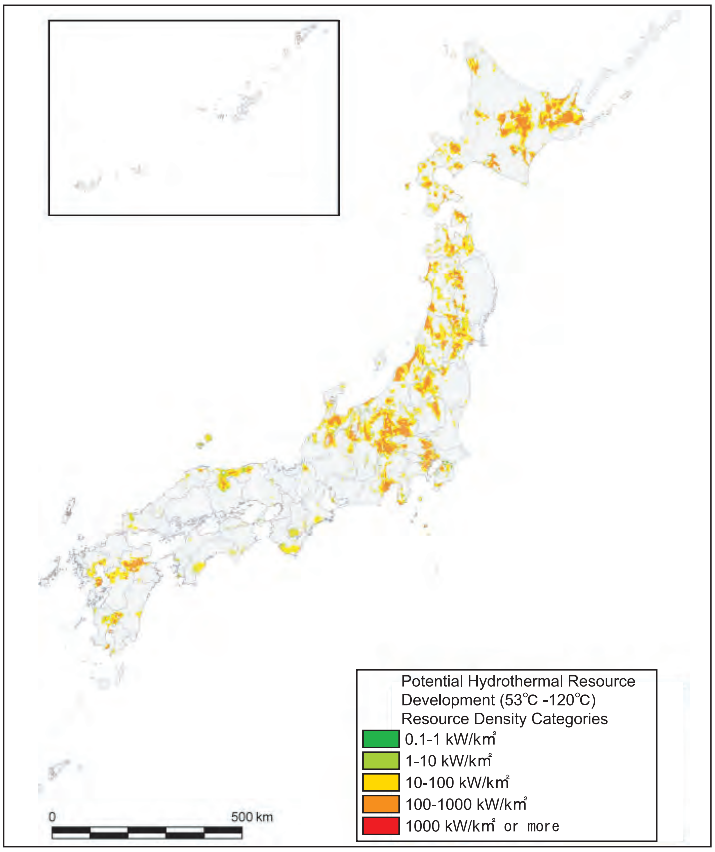


Figure 12 : Distribution Map of Hot Water (53–120°C) Resource Development Potential

Source: Reference[32]

Table 2 : Areas with High Self-sufficiency Rates (Top 10 Areas)

Pref.	Area	Self-sufficiency rate	Main Power
Fukushima	Yanaizu, Kawanuma	3290	Geothermal
Oita	Kokonoe, Kusu	2123	Geothermal
Gunma	Kuni, Agatsuma	1333	Small Hydro
Aomori	Higashidori, Shimokita	1269	Wind
Kumamoto	Itsuki, Kuma	907	Small Hydro
Miyagi	Nishimera, Koyu	774	Small Hydro
Nagano	Sakae, Shimominochi	759	Small Hydro
Yamanashi	Kayakawa, Minamikoma	717	Small Hydro
Iwate	Shizukuishi, Iwate	709	Geothermal
Hokkaido	Tomamae, Tomamae	702	Wind

Source: Reference[41]

Calculation method:
Self-sufficiency rate = renewable energy supply in a district / demand for industries and agricultural uses in the district

water systems[39,40]. To create a sustainable low-carbon society, the impact of shifting to renewable energy for generating heat is greater than the impact of shifting to renewable energy for electricity generation. The use of geothermal energy is expected to substantially contribute to the creation of a low-carbon society. Local production and consumption of energy will be realized through the adoption of geothermal power generation systems based on regional characteristics and the maximum effective use of heat.

The New Growth Strategy aims to increase the proportion of renewable energy up to 10% in the domestic primary energy supply by the year 2020. As Table 2 shows, there are communities that have become more than 100% energy self-sufficient with renewable energy alone. However, it should be noted that energy supplies such as electricity, heat, and power are converted into primary energy equivalents. Regions with geothermal resources can self-supply electricity and heat at the same time, and so, they have potential to become self-sufficient not only in calculation but also in reality.

5-2-2. Revitalizing Regional Industries

It is desirable that energy and food are produced and consumed locally to improve national security and to reduce carbon footprints. Making use of geothermal heat will lead to the creation of communities based on sustainable energy.

In recent years, much attention has been paid to ecotourism[42]. By communicating about local resources to visitors, residents can recognize the value of their own resources. It not only enhances the originality of regional tourism and vitalizes regional economies but also invigorates regional communities. In other words, by rediscovering unique regional appeal, residents can lead a lively lifestyle with confidence in and pride for their community and aim to create a more vigorous and sustainable community. Japan's oldest geothermal power plant, Matsukawa, began operating in 1966 and has been providing part of its geothermal steam to local hot spring inns for air heating. In 1971, the plant began heating steam condensate to provide hot water (60 t/h at 70°C) to the current Hachimantai City Industrial Promotion Corporation and to provide some of the hot water for vacation homes, hotels, and tourist facilities in a hot spring resort settlement in Higashi-Hachimantai. In 1981, the demand for hot water was expected to rise substantially in the settlement and other areas, and the water volume was increased to 200 t/h. Currently, Tohoku Hydropower & Geothermal Energy is providing up to 260 t/h hot water for profit to 38 hotels and inns, 25 recreation facilities, 613 vacation homes, 15 stores, a vacation rental home, a hospital, a retirement home, a one-day hot spring facility, and 95 greenhouses (only during winter) (See Table 1)[43].

Otofuke-cho in Hokkaido uses both heat from hot springs and cold energy from snow and ice to grow Miyazaki mangoes in greenhouses and harvest them during the off-season[44].

The use of excess hot spring water is still at a trial stage in Japan. If other regions can also provide geothermal power as well as a substantial amount of heat resources, not only can energy be produced and consumed locally but also a new large-scale industry may be cultivated.

It is important that, even though new geothermal power plants have not been developed recently, resource survey data has been updated to reduce developers' excavation risks, and small output geothermal power plants have been tested for verification. However, in addition to such bottom-up policies, it will be effective to use geothermal power in top-down policies. It is desirable that different regions compete to draw up their own sustainable and comprehensive innovation plans based on geothermal power generation, and that regions with good model cases receive financial support and be designated as special deregulation zones[45].

Geothermal power plants need to continuously undergo proper maintenance and so constantly require employment. More employment is needed when the plants go through regular inspections, equipment repairs and updates, and drilling of new wells. If we consider this an employment opportunity, it will contribute to regional employment growth. In addition, if a new industry is developed, employment growth will be even greater.

5-3 Lifestyle Innovation Potential

Locations with an abundance of geothermal resources usually have hot springs, and a community can combine both global warming prevention and health-related efforts to attract visitors for business and tourism. For example, it is reported that hotels with geothermal power generation facilities in Kyushu have more overnight guests who visit for the geothermal facilities[43].

The cancer treatment center[46] in Ibusuki city, Kagoshima (opened in 2011) is planning to use binary power generation to cover about 1.5 MW for proton therapy, and for this, the NEDO began a geothermal development promotion survey in 2007[47]. The results suggest that the potential is high, but the plan is not yet in practical use because the binary power generation does not become profitable unless the fixed purchase price is more than 20 yen/kWh in a feed-in tariff system. In Ibusuki, various efforts have been made to have hot springs and geothermal facilities co-exist and co-prosper by, for example, holding active discussion with the residents about the introduction of a geothermal power plant, publicizing the plant's system and the survey results of the well, and conducting a scientific survey showing no impact on hot springs.

These efforts involve both green and lifestyle innovation potential, and in particular in Japan where the population is aging, it is hoped that such efforts will be promoted and established as a business model in many regions.

6 Summary and Proposals

Geothermal energy is a renewable energy source and its energy resources that are equivalent to power generation are estimated to be around 23 GW (more than 10% of the current electricity capacity of general electric power suppliers in Japan). Japan has the third largest reserves in the world, and geothermal energy is one of the few unique resources for the country. However, after a little over 40 years since 1966 (when the oldest power plant, Matsukawa, began operating), the total capacity developed so far is only 540 MW, less than 0.3% of the reserves. This contrasts starkly with the situation in the United States, Iceland, the Philippines, Indonesia, and Italy, where geothermal energy has been rapidly developed. The low price of crude oil until several years ago and the economic downturn are somewhat related to the slow pace of development for geothermal power generation. However, the main factors are that, since geothermal locations often exist in natural parks, a great deal of coordination is required between the government, hot spring operators, and landowners, and numerous environment assessments and other procedures are necessary. Due to these conditions, the lead time between the launch of a development process and the beginning of actual power generation operation is estimated to be more than ten years, and as a result, companies are reluctant to invest in geothermal energy. However, in contrast to solar power and wind power generation, geothermal power generation is not affected by the weather. Therefore, a stable energy supply is possible, and the energy self-sufficiency rate could be improved and CO_2 emissions could be reduced.

Compared with other renewable energy, geothermal energy also has more potential to contribute to regional development in a variety of ways other than power generation. As a source of both renewable energy and as a source of heat, geothermal energy can be expected to greatly contribute to the economy by creating new jobs for local residents through direct and indirect factors, including more construction orders and visitors to the area. In other words, geothermal energy has great potential as a platform to vitalize regional innovation. This fits the concept of “a tourism-oriented nation and local revitalization” described in the New Growth Strategy.

Large-scale geothermal power plants are of course important, but it takes a long time to construct one. In particular, if we want to use geothermal energy for the earthquake recovery, it is desirable to begin with binary power generation and hot-spring power generation since they can be achieved quickly. In the long term, it is essential to develop policies to commercialize enhanced geothermal systems, which can be applied to locations with fewer hot water resources. To this end, the following policies and improvements are desirable.

(1) Revising Related Laws

The Ministry of Environment established an environmental study panel on geothermal power generation and a study panel on the impact of geothermal power generation on hot springs and groundwater, reviewed the guidelines of the Hot Spring Law, and began reexamining regulations. In Japan, no cases have been reported where hot spring resources were depleted due to geothermal development.[43]

(2) Shorter Environmental Assessment Process

An environmental assessment is required to establish a geothermal power plant with over 10 MW output. Currently, an assessment takes at least three years, and it takes more than ten years to begin generating geothermal power. Based on cases overseas, it is desirable to improve Japan’s systems so that the assessment process will be shorter.

(3) Technological Development Support

Geothermal development requires a variety of knowledge and technologies including geology, geochemistry, environmental assessment, and simulation. In particular, for geothermal power generation, it is essential to develop technology to find geothermal reservoirs. Technology for finding geothermal resources with greater certainty has been developed based on seismic observation technology. Japan has been actively conducting earthquake-related research and development, which may be used to extend geothermal development. As discussed in section 2-2-2, the costs and risks when drilling in geothermal development are great. It is hoped that technological development in this area will be promoted because it will reduce the risks for private operators. It is also effective for the national government to take the initiative in studying underground structures in order to reduce the risks of drilling.

Impurities contained in hot water can be deposited to form scale and block pipes and heat exchangers, obstructing operation and causing performance degradation. Existing power plants ensure their operational reliability through appropriate maintenance, but the cost of removing scale is substantial. Therefore, it is essential to develop technology to remove scale at a low cost[16]. These are issues shared by power plant operators, and it is hoped that the government will provide support for technological development.

At the same time, it is important to promote technological development towards the commercialization of an enhanced geothermal system, facilitate efforts to find resources, and to improve binary power generators.

(4) Heat Management

As discussed in section 5-2-2, it is essential to consider geothermal development in a comprehensive manner by, for example, drawing up an integrated regional plan based on geothermal power generation and creating a system where the national government can support the development of a model plan. As discussed earlier, there have been many cases where geothermal power plants provide heat to local communities. However, these communities obtained benefits in return for allowing the plants to be established. Heat is used at new greenhouses and bathing facilities, but it has not reached the point where the energy structures of entire communities are sustainable. For example, while electricity is supplied to areas outside a community, kerosene is still used for heating air in the community. To create a sustainable community, it is essential to manage geothermal heat energy in an integrated manner both for industries and everyday living[49]. There is already a framework that can be used to encourage communities and geothermal power plants to coexist[50], but it is hoped that communities will make their own comprehensive plans, and that a system will be created so that the government can provide support.

(5) Subsidy for Geothermal Development

In August 2011, the Diet passed the law on “Special Measures concerning the Procurement of Renewable Electric Energy by Operators of Electric Utilities”, which fixes purchase prices for electricity generated by renewable energy. This law is expected to be applied to geothermal power generation, too. However, this advantage can be obtained after the launch of plant operation, and so, it is unclear if it will be effective to reduce the risk of having a long lead time, which is typical for geothermal power generation.

The high cost and risk of drilling are key factors in private companies’ reluctance to develop geothermal energy. Therefore, along with technological development support discussed in (3), it is necessary to appropriately reduce risks for individual operators. As discussed in the German case in section 4-4, it may be effective to provide loans for the drilling phase since it requires substantial funding, as well as to compensate for losses if drilling fails. Solar power generation drastically increased after a subsidy system was restored, and subsidies are essential for geothermal power generation, too.

7 Conclusion

Since the Great East Japan Earthquake, much attention has been paid to renewable energy and geothermal power generation. In July 2011, some private companies announced that they were going to construct a large-scale geothermal power plant in the Tohoku region by 2017. The Tohoku region, which is recovering from the earthquake, has an abundance of geothermal energy. Since the region has a relatively cold climate, the benefit from a sustainable heat supply is greater than it would be in a region with a warmer climate. When the earthquake hit that region, it was cold and snowing lightly, and energy was necessary to stay warm. Geothermal energy can be used both for power generation and direct heat supply, and there is no question that geothermal energy can greatly contribute not only to the people living in the earthquake-stricken area but also to the prevention of global warming.

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2

Trends and Problems of Seismological Research in Japan in Light of Two Major

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1 Introduction

The two earthquakes to which the title refers are the 1995 Great Hanshin-Awaji Earthquake (M7.3, 6,437 dead and missing) and the Great East Japan Earthquake (M9.0, approximately 20,000 dead and missing). When we look back on past earthquakes in Japan, including these two, Japan has experienced thirty-one earthquakes that left ten or more dead and missing in the 20th century, occurring at an average interval of 3.2 years. In the first eleven years of the 21st century, Japan was struck by four such earthquakes that indicate the pace is not slowing: the 2004 Chuetsu Earthquake, the 2007 Chuetsu Offshore Earthquake, the 2008 Iwate-Miyagi Inland Earthquake and the 2011 Great East Japan Earthquake. In other words, if a warning had been issued that an earthquake like these would strike somewhere in Japan about once every three years, then it would have been correct. This prediction may or may not be valid in the future. Assuming that it will, its effectiveness would be ironic compared to earthquake predictions for specific areas, which are rarely accurate. This is because while we cannot stop earthquakes from happening, we can act to limit the extent of the damage they cause.

The orientation and structure of Japanese seismological research underwent major change after the Great Hanshin-Awaji Earthquake. Even so, this latest disaster has again instigated change in the field; but in what way?

It just so happens that this shift has been spelled out in the 4th Science and Technology Basic Plan (adopted by a cabinet decision on August 19th, 2011).[1] This document acknowledges that, based on the disaster and nuclear accident, the country's risk management was insufficient and that an issue to tackle will be how to educate the public about science and technology and restore their trust in it. The plan also calls for the promotion of initiatives such as research and development to enhance our ability to respond to natural disasters and keep the public safe.

This paper reflects on the implications the Great East Japan Earthquake has for seismology, while also considering the state of seismological research in Japan in a comparison to the United States that is based on the number of and trends concerning their seismological societies' research presentations.

2 The Great East Japan Earthquake

2-1 An Overview of the Earthquake

At 2:46 p.m. on March 11th, 2011, a massive M9.0 earthquake struck under the Pacific Ocean, affecting an area from Tohoku to Kanto. (The earthquake was officially named the "2011 Earthquake off the Pacific Coast of Tohoku" by the Japan Meteorological Agency). This was the strongest earthquake ever recorded in Japan. There were roughly 20,000 dead and missing due to the seismic intensity and the tsunami that followed.

This earthquake was caused by sliding along the boundary between the Pacific Plate, which is subducting under the Japan Trench, and the continental plate atop which sits the Tohoku region. Figure 1 shows the distribution of slippage on the fault plane, based on an analysis of data from the GEONET ground-based GPS observation network conducted by the Geographical Survey Institute of Japan (GSI) the day after the earthquake.[2] The slippage is centered around the epicenter in the waters off the Miyagi Prefecture. A 500 km x 200 km area around the focal region experienced slippage of up to 24 meters, stretching from off the Iwate Sanriku coast to off the coasts of Miyagi, Fukushima and Ibaraki prefectures.

Whereas the Great Hanshin-Awaji Earthquake occurred along an active fault below an urban area, this latest earthquake struck at a plate boundary along an ocean trench. Thus, two different types of major earthquakes struck in a sixteen-year timeframe.

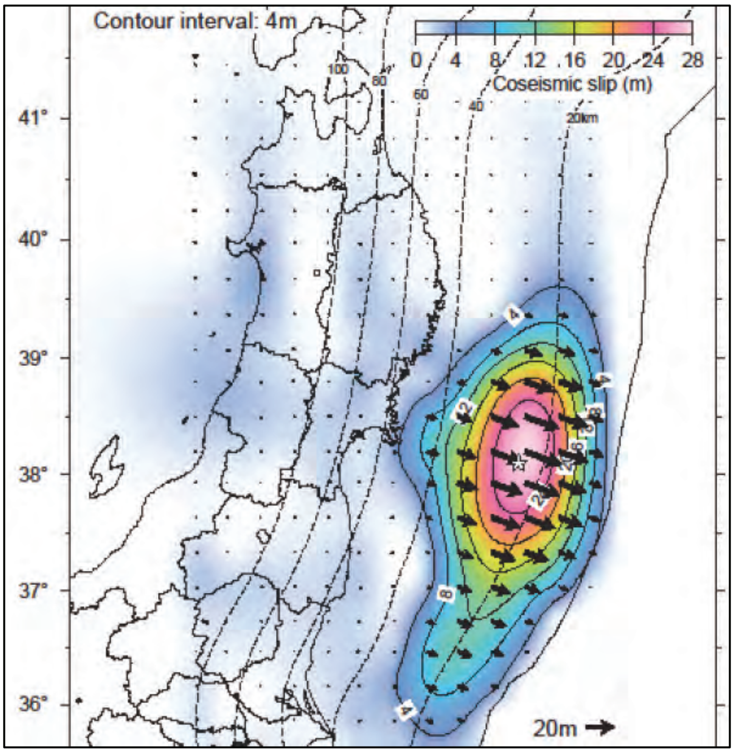

Figure 1 : Distribution of Slippage on Plate Boundary
Source: GSI[2]

2-2 Prior Prediction

The Headquarters for Earthquake Research Promotion (HERP) established by the government after the Great Hanshin-Awaji Earthquake conducted earthquake likelihood assessments off eastern Japan's Pacific coast prior to the Great East Japan Earthquake.[3] Beginning with the assessment report on seismic activity off the coast of Miyagi Prefecture released in November 2000, HERP has divided the area into eight zones (see Figure 2; A: North off-Sanriku, B: Central off-Sanriku, C: Off-Miyagi Prefecture, D: Off-Fukushima Prefecture, E: Off-Ibaraki Prefecture, F: Off-Boso, G: South off-Sanriku Japan Trench Approach, H: North off-Sanriku to off-Boso Japan Trench Approach). Except for zones B and F, HERP released figures on the likelihood of earthquakes occurring over the next thirty years in each zone and their predicted magnitude (referred to as a "characteristic earthquake" if the focal region can be pinned down). Earthquake likelihoods are updated annually. Figure 2 shows thirty-year probabilities as of January 1, 2011.

By comparing Figures 1 and 2, we see that the recent earthquake was due to sudden slippage in six of the eight zones (B, C, D, E, G and H inside the oval in Figure 2). Looking at the historical record, we find no past combination of an earthquake and tsunami in this area like this one. The focal region of the Meiji-Sanriku Tsunami Earthquake that struck in June 1896 (M8.2) was off the coasts of Iwate and Miyagi prefectures, near the Japan Trench, which corresponds to Zone H in Figure 2. The maximum run-up height of this earthquake's tsunami was estimated at 38.2 meters and it killed 22,000 people. Although this earthquake was not as strong as the M9.0 Great East Japan Earthquake, the tsunami magnitude (Mt) was of comparable scale, measured at the maximum value of 9.0.[4] Furthermore, there was a series of M7-M8 seismic events in zones E, H, C and G (in that order) during a year-and-a-half period in 1896 and 1897, before and after the Meiji-Sanriku Tsunami Earthquake. This was caused by slippage occurring over a relatively short period of time, much of which had a focal region over the edge of the Pacific Plate.

So can we say that the Great East Japan Earthquake is a recurrence of what happened 120 years before? From a seismological point of view, the successive slippage in each zone's focal region occurring 120 years ago is completely different from the simultaneous slippage that happened within a few minutes this time. The total moment magnitude (Mw) (the simple arithmetic sum of the energy released) of these characteristic earthquakes, etc. is only Mw8.4, whereas the Great East Japan Earthquake's was M9.0, or about ten times more energy. Furthermore, if the Pacific Plate subducts at a speed of around 8 cm a year, then it cannot amass slippage of more than 24

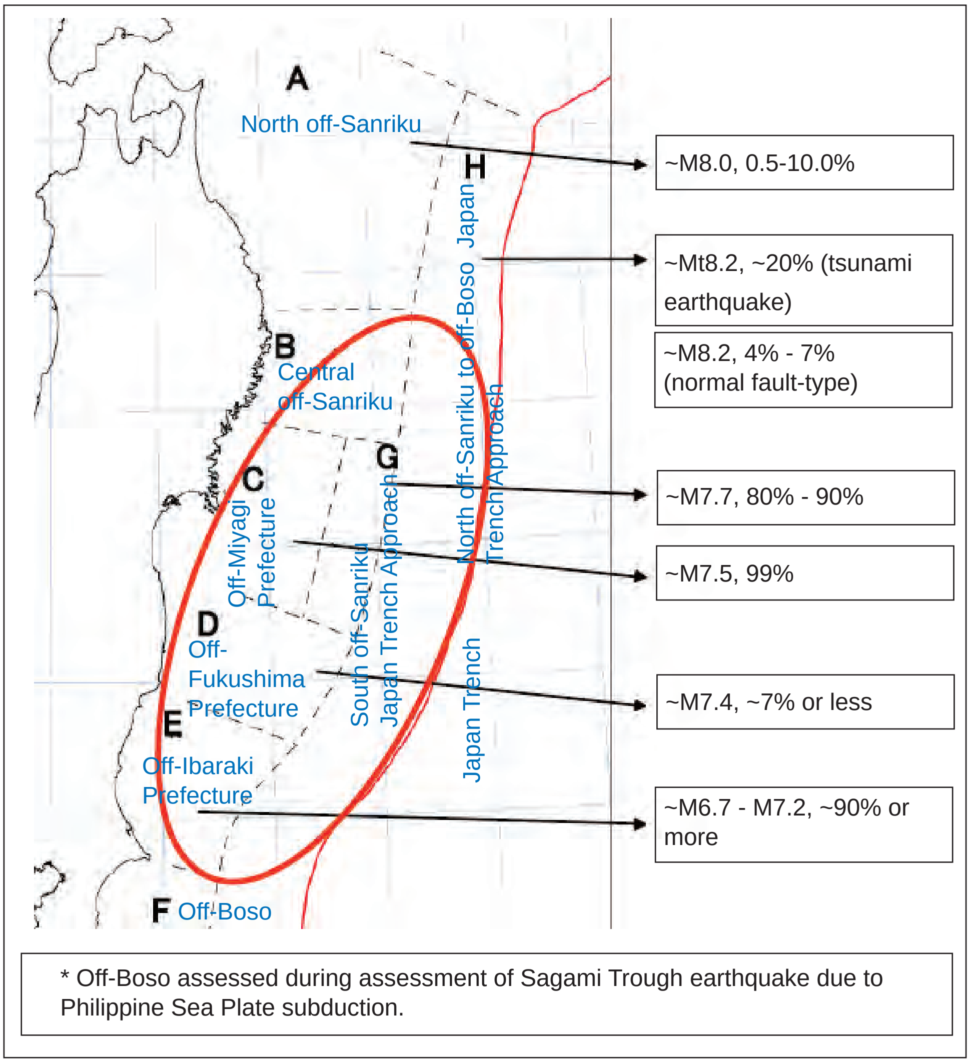

Figure 2 : Seismic Zones and Earthquake Likelihood Predictions Released by HERP
Figure shows predicted magnitudes and 30-year likelihoods.

Compiled by STFC based on HERP materials[3]

meters over 120 years. Accordingly, it is incorrect to view this earthquake merely as one of a series of "interconnected earthquakes" shown in Figure 2. Thus, we are forced to rethink how earthquakes in this area occur.

Prior predictions had assumed an M7 or M8 earthquake would hit off the coast of Miyagi Prefecture in the near-future. However, it was not thought that an M9 earthquake would occur in this area. The basis for this was taken from the conjecture in "Comparative Study of Subduction" as pointed out by Shimazaki(2011)[5]. Ruff and Kanamori (1983)[6] provided two parameters for earthquake size in a subduction zone: subduction speed and plate age. Applying this theory, we can estimate that the typical magnitude of earthquakes occurring off the Sanriku coast is around M8.1. Sumatra was similar. However, both the 2004 Sumatra-Andaman Earthquake and the Great East Japan Earthquake were actually M9. We can now say that there is a problem with the hypothesis.

There is nothing odd about testing whether a theory's hypothesis corresponds to reality and then switching to another theory. Five M9 earthquakes have occurred along the Pacific Rim in the past half-century. Thus, a cool-headed analysis would find an M9 earthquake hitting the coast of Japan as unsurprising. In a sense, the problem now is that a leading theory deprived us of the freedom to come up with other ideas. It is perfectly normal in science to weed out any number of hypotheses as we make scientific advances. However, seismology has another dimension in that it has the worrying problem of its hypotheses being directly related to people lives. Although we should avoid coming to fast conclusions, the public needs to recognize or prepare to accept the fact that, to say the least, the researchers' work does not always have beneficial effects.

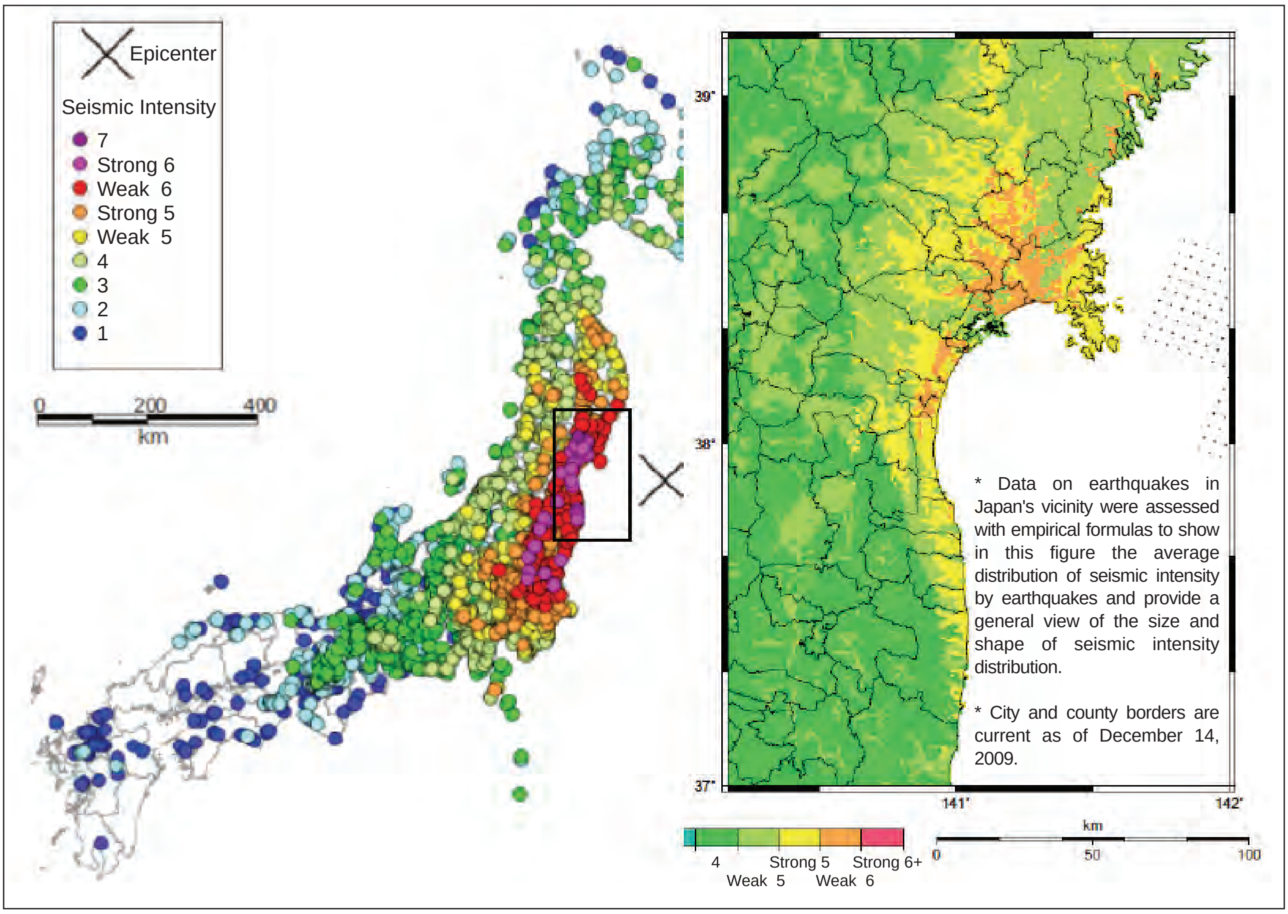

Figure 3 : Distribution of Seismic Intensity from Great East Japan Earthquake (left) and Predicted Distribution along Miyagi Prefecture Coast (right)

Sources: HERP[7], Association for the Development of Earthquake Prediction

2-3 Research on Off Miyagi Prefecture Earthquakes

Figure 3 compares the distribution of HERP's[7] seismic intensity predictions for earthquakes off the coast of Miyagi Prefecture (Zones C and G from Figure 2; right side of figure) and the distribution of observed seismic intensity from actual earthquakes (left side of figure; based on data from the Association for the Development of Earthquake Prediction). While the left side of the figure shows a wide area around Miyagi Prefecture experiencing seismic intensity of at least 6-lower, the hazard map on the right only labels an area with seismic intensity of at least 6-lower on part of the Kitakamigawa watershed and the coast of Sendai Bay, demonstrating a major discrepancy between assumptions explained in the previous section and reality.

However, this does not mean that HERP's assumptions were meaningless. At the least they created a sense of danger over an imminent major earthquake off the coast of Miyagi Prefecture. It is not easy to examine to what extent these assumptions reduced the actual damage caused by the Great East Japan Earthquake, but because of them, earthquake resistance measures were promoted in and around the City of Sendai. It would be hard not to imagine that these efforts paid off.

In addition, HERP started up a priority survey and observation project, the "Priority Survey and Observation of Off-Miyagi Prefecture Earthquakes,"which involved five years of comprehensive surveys and analysis from 2005 to 2009. The project was conducted by up to fifty-nine researchers and produced a lengthy 411-page final report. A notable part of the report is one that lists three major tsunamis: the 869 Jogan Tsunami, the 1611 Keicho Tsunami and the 1793 Kansei Tsunami. The report states that giant tsunamis like these reoccur every 450 to 800 years or so. Considering that most of the casualties as well as the problems caused by the nuclear power plant accident were caused by the tsunami, it is truly unfortunate that the timely insight obtained through this project was not adequately utilized before the disaster.

Although the timing of this major disaster was unfortunate, the policy and research project conducted by HERP, a government organization established as a response to the Great Hanshin-Awaji Earthquake,

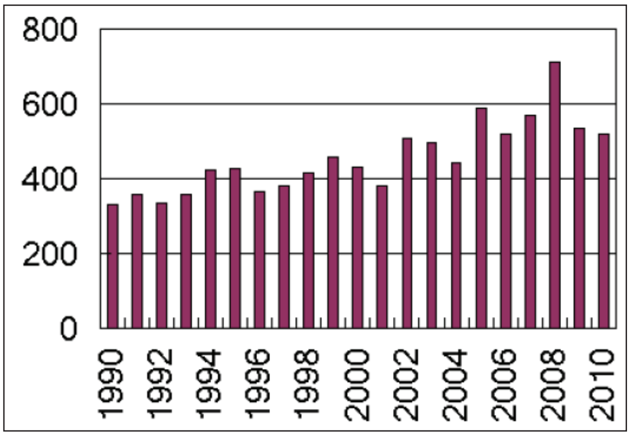

Figure 4 : Number of Presentations at SSJ Fall Meetings
Compiled by STFC

is fundamentally "mission-oriented" research with clearly defined goals. So just what path did the orientation of the scientists' research take after the Great Hanshin-Awaji Earthquake?

3 Trends in Japanese and U.S. Seismological Societies

This chapter examines seismological societies in Japan and the United States to compare the orientation of research conducted by scientists from each. First, we will look at seismological research trends by focusing on papers presented by the Seismological Society of Japan (SSJ). Although the SSJ does not provide a view of the field in its entirety, most Japanese seismologists are members, making it valid as the most comprehensive place relating, at the least, to seismological research as physical science in Japan.

An important point about the SSJ is that while it is a single society, there is no substantive force holding its membership together. In other words, individual society members decide what papers to present; the orientation these papers take does not reflect any particular intent of the society. However, as a result of this, the publications provide an objective look at the field's overall research trends at the time.

The SSJ normally announces papers semiannually at its spring and fall meetings, but since 1990 the spring meeting has been a joint event with other geophysical societies: the Society of Geomagnetism and Earth, Planetary and Space Sciences (SGEPSS) and the Volcanological Society of Japan (VSJ). Thus, only the fall meetings were the subject of the below research.

3-1 Japanese Seismological Research Before and After the Great Hanshin-Awaji Earthquake

The deaths of more than 6,400 people killed by the Great Hanshin-Awaji Earthquake in 1995 were a powerful shock to the entire field of seismology at the time. The Headquarters for Earthquake Prediction Promotion, a group within the Science and Technology Agency, (now the Ministry of Education, Culture, Sports, Science and Technology) was reorganized into the Headquarters for Earthquake Research Promotion, drawing up seismic intensity hazard maps for all of Japan as reported earlier in Science & Technology Trends.[8] Seismological societies corrected what had been an excessive importance placed on studying earthquake prediction and directed the basic focus of research on applying physical science to reveal earthquake mechanisms.

Figure 4 shows the number of paper presentations at the fall meeting over the past twenty years. Since the number of presentations permitted for each member per meeting is limited, we can consider these figures as being roughly proportionate to the total number of researchers. Although there was not a sudden increase due to the Great Hanshin-Awaji Earthquake, we can surmise that there has been a steady rise in the number of seismologists (including university students). It should be noted that the sudden protrusion in 2008 was due to a joint meeting with an international society.

The issue is not how many papers there are, but what they are about and their orientation. The author has tried categorizing the papers based on their titles, as he believes that one can figure out the research's orientation from the title. Figure 5 is a comparison of the meeting prior to the Great Hanshin-Awaji Earthquake (fall 1994)[9] and the fall 2010 meeting[10] sixteen years later. The figure gives the name of each meeting session and the number of papers presented. Other than the special sessions in the lower part of each list, many names of sessions in the two academic years have not changed at all. Of course, the content of each kind of research develops year-by-year while surely some sessions adopt very different styles. However, the point here is not how much seismology has changed scientifically, but whether the orientation of individual scientists' research is incorporating the mission since the Great Hanshin-Awaji Earthquake and whether this indicates that the trend within the society as a whole is changing direction. To discuss

1994 (Fukuoka)	
Crustal and Ground Structures	23
Crustal Movements	17
Seismic Activity and Earthquakes in General	44
Focal Mechanisms	34
Seismic Waves and Theory	16
Ground Movement and Earthquake Damage	25
Historical Earthquakes	7
Tectonics and Seismotectonics	30
Earthquake Prediction	11
Geochemistry and Underground Water	5
Active Faults, Gravity and Planets	18
Rock Failure and Stress	8
Inner Earth Structures, Physical Properties and Thermology	24
Tsunami and Magnitude	12
Measurement and Processing Systems	19
Numerical Waves and Strong Motions	46
Inland Earthquakes	33
Volcanic Tremors	25
The Unzen Volcano	13
Bolivian Deep Earthquakes	14
Total	424

2010 (Hiroshima)	
Crustal Structures	37
Crustal Movements, GPS and Gravity	44
Seismic Activity	35
Earthquakes in General, etc.	13
Earthquake Theory and Analytical Methods	21
Ground Structures and Movements	32
Geothermics	1
Tectonics	8
Earthquake Prediction	17
Geochemistry and Underground Water	2
Active Faults and Historical Earthquakes	15
Rock Experiments and Ground Stress	9
Deep Structures and Physical Properties of the Earth and Other Planets	16
Tsunami	17
Earthquake Measurement and Processing Systems	12
Strong Motions and Earthquake Damage	48
Various Earthquake-related Phenomena	4
New Seismic Waveform Anatomy	49
The Physics of Earthquake Occurences	54
Challenges in Studying Changing Topography: From Active Faults to Seismic Motions	13
Towards the Construction of Earthquake Prediction Systems Based on Seismic Activity Assessments	21
The Philippine Sea Plate and the Japanese Archipelago: From Earthquakes and Volcanoes to Land Formation Theory	40
Memorial Lectures	3
Earthquake Education and the History of Seismology	7
Total	518

Figure 5 : Session Names and Number of Presentations at SSJ Fall Meetings (1994 & 2010)

Compiled by STFC

them the author has, albeit somewhat arbitrarily, inferred the research topics from individual paper titles and classified them into four categories (1: academic and physical science research on the structure of the Earth's crust, earthquake mechanisms, etc.; 2: earthquake prediction/forecasting; 3: seismic intensity assessment and damage prediction; 4: other). These categories are no more than comparative classifications based on the author's impressions. In addition, these categories were made with the following section's comparison with American seismological societies in mind.

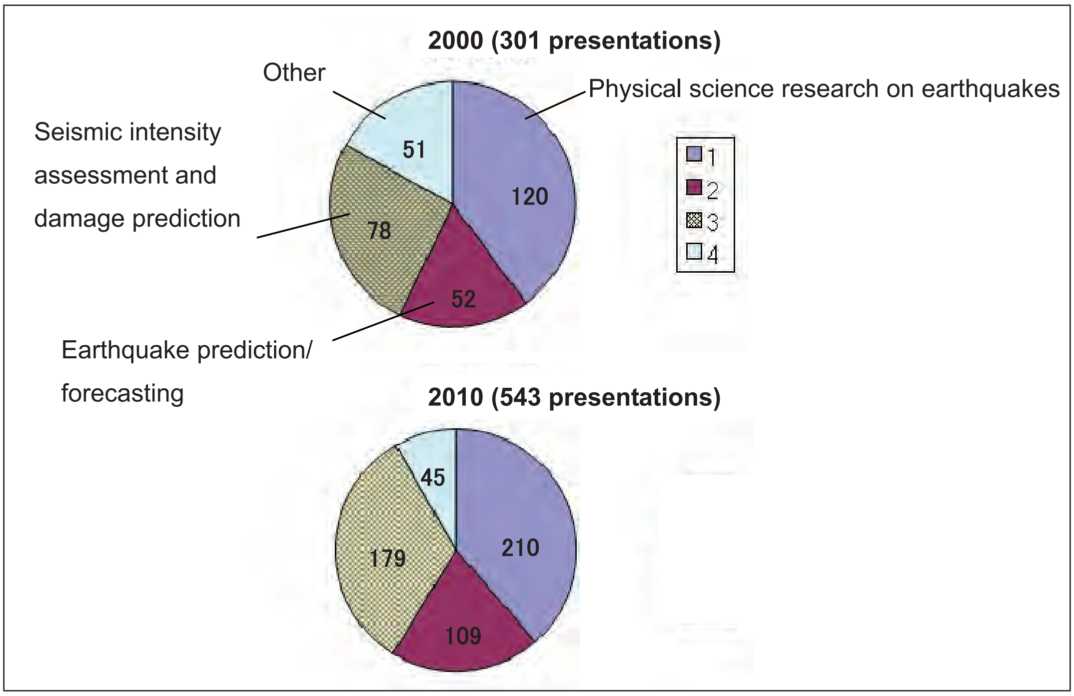

Figure6 : SSJ Presentation Themes Based on Presentation Titles
Figures are number of presentations

Compiled by STFC

3-2 Comparison between Japan and U.S. Seismological Societies

The author also used the categories to make a comparison with the Seismological Society of America (SSA). The U.S. west coast experienced a series of medium-strength earthquakes around twenty years ago: the Loma Prieta Earthquake in 1989 (M6.9, sixty-three dead), the Landers Earthquake in 1992 (M7.3, 400 hurt) and the Northridge Earthquake in 1994 (M6.7, fifty-seven dead). The author examined papers presented thereafter in 2000[11] and 2010[12] at regular meetings. The number of papers was 301 and 543, respectively, displaying a large increase that fairly rivals Japan's in recent years. Furthermore, the session names are listed in Figures 7 and 8. The author made literal Japanese translations of the titles himself in the original Japanese version of this paper. The SSA uses long session names and never uses a name more than once. In the U.S., one feels that session names have a “mission orientation” to clarify the goals and meaning of the research.

It is impossible to clearly judge from session names and presentation titles alone whether there is a mission orientation extending to the substance of the research. Rather, perhaps it is commonly thought that there are no national or other differences in the way that fundamental research is conducted. However, although these are differences on the surface, we cannot dismiss the impression that there are differences in research orientation and attitude.

Figure 9 is the result of a comparison of presentation titles, categorized by subject area, between 2000 and 2010. Although the classification is simple and subjective, there is a clear difference between Japan and the U.S. when we compare it to Figure 6. In the U.S., the second and third subject areas together make up around 50% of the total. Figure 10 contains excerpts from each seismological society’s website stating the purpose or intent for their establishment. Keeping in mind the analysis and results presented in this section, as we read them we notice that the American society expresses more strongly how its intentions relate to the wider society.

3-3 The Meaning Expressed by “Implication”

The results of the comparison between session names and presentation titles by the Japanese and American seismological societies show that there is a weak sense of mission in research by Japanese scientists. In fact, the author has one more reason for having this impression. Non-Japanese papers frequently use the term “implication” in their titles and introductions. The dictionary definition in Japanese is gan’i, a word that Japanese find somewhat difficult to use. However, this word does more than simply accurately convey the content and results of research; it emphasizes the

2000 SSA Meeting (San Diego, California)	
Recent Topical Earthquakes	25
The Interface between Engineers and Seismologists	14
Earthquakes in General	11
CTBT Monitoring and the Global Seismic Network	40
3D Imaging of the Earth's Crust	20
Accounting for Site Effects in Probabilistic Seismic Hazard Analysis	36
Near-surface Geophysical Imaging	14
Seismology in Education	13
Seismology and the NSF Earthscope Initiative	14
"Terra Scale" Computing and Earthquake Science	10
Interfacing Seismology with Other Geophysical Disciplines	9
Combined Use of Seismic and Geodetic Data	19
Seismic Arrays of the Future: "Zero Maintenance" Stations/New Technology and Telemetry	16
Seismic Events through the Ages	26
Seismology and Volcanoes	6
Seismic Structures, Big and Small	11
Strong Motions and Probabilistic Seismic Hazards	17
Total	301

Figure 7 : SSA Session Names and Number of Presentations (2000)

Compiled by STFC

2010 SSA Meeting (Portland, Oregon)	
Building Code Uses of Seismic Hazard Data	10
Monitoring for Nuclear Explosions	34
Characterizing the Next Cascadia Earthquake and Tsunami	17
Magnitude Scaling and Regional Variation of Ground Motion (jointly sponsored by the European Seismological Commission)	24
Advances in Seismic Hazard Mapping	23
The Evolution of Slow Slip and Tremor in Time and Space	21
Seismic Imaging: Recent Advancement and Future Directions	19
Engaging Students and Teachers in Seismology: In Memory of John Lahr	11
Joint Inversion of Multiple Geophysical Data Sets for Seismic Structure	6
Ground Motion: Observations and Theory	4
Seismological Methods: Techniques and Theory	8
Numerical Prediction of Earthquake Ground Motion	37
The Seismo-Acoustic Wavefield: Fusion of Seismic and Infrasound Data	21
Operational Earthquake Forecasting	18
Near-Surface Deformation Associated with Active Faults	27
Quantification and Treatment of Uncertainty and Correlations in Seismic Hazard and Risk Assessments	15
Earthquake Debates	12
Seismic Structure and Geodynamics of the High Lava Plains and Greater Pacific Northwest	16
Deterministic Simulated Ground Motion Records under ASCE 7-10 as a Bridge Between Geotechnical and Structural Engineering Industry	12
Recent Advances in Source Parameters and Earthquake Magnitude Estimations	24
Local Observations of the January 12, 2010 Haiti Earthquake (Mw7.0)	1
The January/February 2010 Earthquakes in Haiti, Offshore Northern California, and Chile: Origins, Impacts and Lessons Learned	38
Volcanic Plumbing Systems: Results, Interpretations and Implications for Monitoring	19
Subsurface Imaging for Urban Seismic Hazards at the Engineering Scale	23
State of Stress in Intraplate Regions	19
Statistics of Earthquakes	15
Seismology of the Atmosphere, Oceans, and Cryosphere	12
At the Interface Between Earthquake Sciences and Earthquake Engineering in the Pacific Northwest	9
Seismicity and Seismotectonics	18
Time Reversal in Geophysics	11
Seismic Hazard Mitigation Policy Development and Implementation	7
Seismic Networks, Analysis Tools, and Instrumentation	12
Total	543

Figure 8 : SSA Session Names and Number of Presentations (2010)

Compiled by STFC

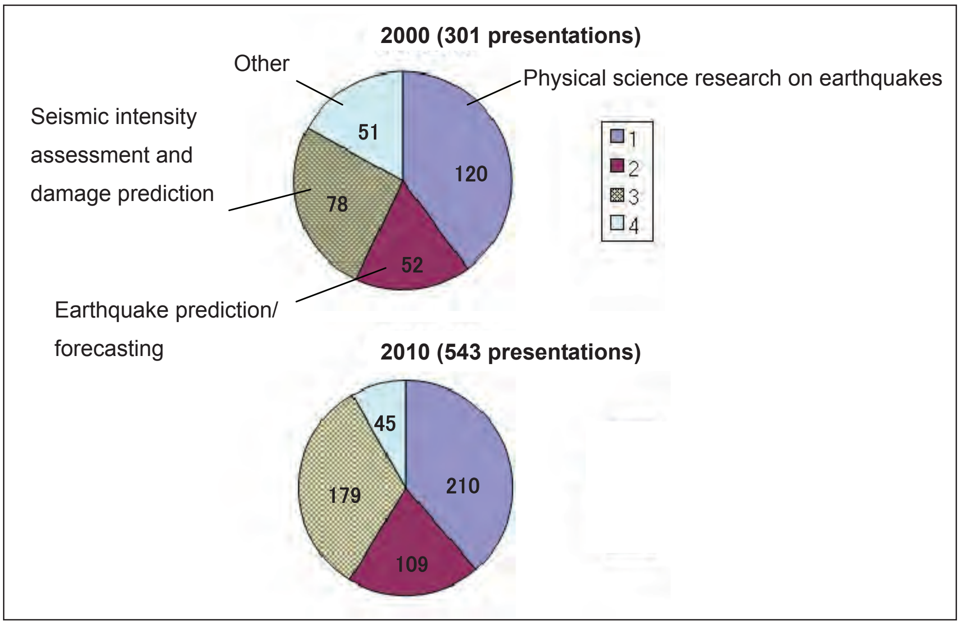

Figure 9 : SSA Presentation Themes Based on Presentation Titles
Figures are number of presentations

Compiled by STFC

SSJ's Mission Statement:	The objective of the SSJ is the development and expansion of seismology and to contribute to the growth of scholarship in Japan through partnerships with related academic societies in Japan and abroad as well as the exchange of knowledge and publication of research on science and practical uses concerning seismology (SSJ homepage[13]).
SSA's Mission Statement:	The Seismological Society of America (SSA) is an international scientific society devoted to the advancement of seismology and its applications in understanding and mitigating earthquake hazards and in imaging the structure of the earth (SSA homepage[14]).

Figure10 : Japan and U.S. Seismological Society Mission Statements

Source: References[13,14]

tenor that conveys the strong intent of the author. If Japanese people use the term “implication” in few of their research presentations, is it simply a difference in vocabulary usage? But the author would dare to say, in recognition of the risks involved in making sweeping generalizations, that when selecting topics for research presentation, Japanese researchers do not have a strong-willed attitude on the position that they want their research to promote: what the purpose is, what they want to emphasize.

After the Great East Japan Earthquake, the Asahi Shimbun[15] newspaper printed the following critique: “[Japanese] seismologists put all their effort in examining the epicenter.” One could dismiss this as a careless generalization, but in fact, the author feels the same way. There is no mistake that analyzing the characteristics of the epicenter is a basic part of seismological research, and that it certainly opens the way to follow-up research on earthquake disaster prevention. However, on the other hand, one often wants to press the question, “I see. Now we have a good understanding of the epicenter’s characteristics... So, with that information, what does that tell us about what do next?” Presenters may not give thought to stating the purpose of their research, but it is not always obvious to the audience.

4 Observations

From a layman’s point of view, seismology is more than just a field within earth science: it is a way to confront the threats that nature poses to our lives. This means that we should think of seismology’s goal as being earthquake and earthquake damage prediction – the second and third categories discussed in the preceding chapter. The end goal of the first category, academic and physical science research, has always been earthquake prediction. There was nothing mistaken about shifting from an overemphasis on phenomenological earthquake prediction research, which was popular until the Great Hanshin-Awaji Earthquake, to a return to basics by using physical science to reveal earthquake mechanisms, and this line of thought is still valid. However, no matter how much we discover about their mechanisms and make advances in earthquake-related physical science, that alone will not automatically help us prevent damage caused by actual earthquakes. To take this point a step further, if we study nature through physical science, there is a tendency to become fixated on the study itself. Considering only the current situation, it is difficult to say the effects that major earthquakes have had on seismology have resulted in aligning its orientation with the public's expectations.

Since the Great Hanshin-Awaji Earthquake, Japan has constructed a nationwide network for making basic observations of earthquakes and seismic activity and has started up numerous special research projects. The result has been that much seismology has been conducted by joining in project research based on data from this basic observation network. This sort of research was already in a position that needed a sense of mission. But if in spite of this the result has been that SSJ research trends have not experienced significant change following major earthquakes, then what is the reason for this?

The author does not believe that there is a substantive difference between the quality of Japanese and American researchers or in their research ambitions. Furthermore, the author does not doubt that researchers are primarily motivated to study by their strong curiosity about natural phenomena, supported by a sense of mission that tells them to use the results to improve people's lives. However, at the same time the author does very much perceive that professional researchers live in a research setting that establishes their identity. We cannot expect researchers not to care about how their research is evaluated and how those evaluations will affect their futures. In the end, even if they have a sense of mission, the biggest reason why individual researchers take different directions is the way they are evaluated. For example, the study of earthquakes can largely be divided into two kinds of analysis: spatial structure and temporal variation. Since the latter requires the patient accumulation of data over a long span, it is difficult to produce results in a short time. Therefore, the result may be that young researchers distance themselves from research on temporal variation.

Based on the lessons from the Great East Japan Earthquake, HERP will likely take the lead in beginning new mission-oriented research projects at universities and independent administrative institutions. Of course, such new projects have to provide a clear mission to receive funding. However, if the project merely advertises its mission for self-promotion, then that feeling will not automatically be shared by the individual researchers involved. The worry is that if we compare today's SSJ presentations with those given ten years from now, they may produce the same results as today's research. If we require projects to truly have missions, then we will need to consider how to evaluate individual researchers, as well as of course the projects themselves. That is to say, the problem is related to the ability of the people managing research and the task at hand is to ask them to display true leadership.

5 Conclusion

After the Great Hanshin-Awaji Earthquake, Japanese seismology defined its goal as revealing earthquake mechanisms based on physical science. In a sense it can be said that this was a valid goal to set. However, considering the present situation, the result seems to be a divergence opening up between the research's orientation and what the public expects from seismology.

This paper has attempted to speculate on seismological trends in Japan by comparing the differences in how papers are presented in the Japanese and American seismological societies. This research has depended on a good deal of arbitrary and subjective impressions, but it does in fact seem that there is some sort of disparity in researcher attitude and direction in each country and the author has concluded that it is due to the different degree to which they feel a sense of mission. In normal times, the author would also simply regard this as a difference in research culture, and the author is not arguing that Japanese seismology should take on the mission orientation of America's research culture. Be that as it may, the Great East Japan Earthquake is a very serious, abnormal situation, for all of seismology. The author believes that we can no longer allow researchers to stay secluded within their field as they decide on seismology's goals and how to conduct research.

When the 2009 L'Aquila Earthquake (M6.3) struck Italy, the media reported that the authorities accused a local seismologist of not releasing appropriate predictions. This was a symbolic incident showing what seismologists' motivation and intentions are regarding their research as well as the fact that they cannot avoid the direct relationship seismology has on real people's lives.[16] This news also shook the field of Japanese seismology. The excitement pushed the SSJ to issue a statement of protest to the Italian authorities, as Japan's national character makes it difficult for Japanese researchers to imagine such an incident occurring in the first place. However, the author cannot erase his concern over how far the Japanese people will tolerate spending tens of billions of yen every year[17] on earthquake research without producing results that benefit the public. All researchers engaged in seismology should take a second look at their research and consider what the "implications" are.

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Profile

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3

Expansion of Market Mechanisms that Sustain Ecosystem Services —Certification Systems to Promote Ecosystem Conservation in Daily Consumption—

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1 Introduction

Two major conventions were adopted at the United Nations Conference on Environment and Development (UNCED), also known as the Earth Summit, held in Rio de Janeiro, Brazil in June 1992: the United Nations Framework Convention on Climate Change (UNFCCC) and the Convention on Biological Diversity (CBD).[1] Essential discussion on relationship between human activity and the Earth began to take shape at this time.

The UNFCCC's goal is to stabilize the concentration of greenhouse gases in the atmosphere. Under this convention, the Kyoto Protocol was agreed at the 3rd session of the Conference of the Parties of the convention (COP3) in Kyoto in 1997. The protocol stipulated binding greenhouse gas emission cuts for developed countries.[2] Since then there has been a growing global interest in the problem of global warming and the general public has become aware of the importance of energy-saving and green initiatives. Concern over global warming's impact on our lives is becoming more widespread, as exemplified by companies that include environmental accounting as part of their performance reports, as well as Japan's Eco-points system coupled with subsidies and other policy measures to expand the market for energy-saving products.

Meanwhile, the CBD recognizes three levels of biodiversity – "ecosystems," "species" and "genes"– with the purposes of conserving biodiversity, the sustainable use of its components and the fair distribution of the benefits gained from the use of genetic resources.[3] Under this convention, in 1995 Japan formulated the National Biodiversity Strategy of Japan. Based on two later discussions concerning modifications to the strategy, Japan developed policies to promote conservation and sustainable use.[4] The Diet passed the Basic Act on Biodiversity in May 2008. In accordance with this law, the National Biodiversity Strategy of Japan 2010 was adopted by a cabinet decision as a concrete strategy (with roughly 720 specific measures and thirty-five numerical targets).

Although both Convention got started at the same time in this manner and were put together via similar decision-making bodies and discussion arrangements, one thing that has changed much in the present is the public's awareness level concerning global warming and biodiversity. According to the Survey on Environmentally Friendly Corporate Behaviors[5] released by the Ministry of the Environment in December 2010, 59.4% of companies that responded said their corporate management has "set policies and implemented on preventive measures" concerning global warming, while only an extremely low 17.2% of companies answered that conserving biodiversity was "closely related to business activity and is important."

Against these, five bodies including the International Union for Conservation of Nature (IUCN) and Shell International Limited published "Building Biodiversity Business"[6] in 2008, which declares: "Action is urgently required to halt the loss of biodiversity, but governments and nongovernmental organizations (NGOs) cannot do it alone." The document also states that there is a pressing need for the business sector to participate in conservation efforts. Estimates put human activity's current ecological footprint, a measure of our impact on the environment, at over 40% of the Earth's biological capacity.[7] Policies that has a global sense of urgency utilizing market mechanisms are required.

This paper will provide an overview of ecosystem services and effective methods and scheme to promote the conservation of biodiversity and ecosystems.

2 Overview of Ecosystem Service and Ecosystem Conservation

2-1 Definition of Ecosystem Service

In 2005, the Millennium Ecosystem Assessment (MA),[8] a global ecosystem assessment established in 2001 at the behest of the United Nations, conceptualized relationship between humans and ecosystems/biodiversity that had until then been an ambiguous: "'Ecosystem services' are the benefits provided by ecosystems to humans, which contribute to making human life be rich and comfortable" (see Figure 1). The MA defined four categories of ecosystem service functions and summarized their relationship to the lifestyles and benefits received by humans (see Figure 2). Demonstrating this relationship, the fact is that quite extensive things such as, of course, our everyday lives, as well as others ranging from components of public services to commercial activity in the private sector, depend on ecosystem services.

Biodiversity, the variety of living creatures, supports the biological environment that is a component of an ecosystem. An ecosystem and biodiversity are mutually dependent upon each other. Both conserving

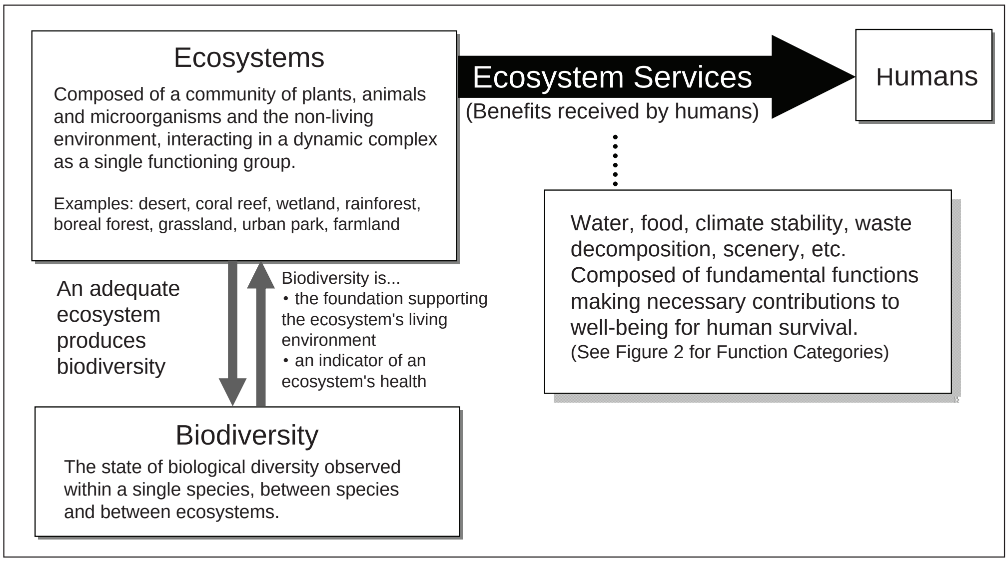

Figure 1 : Concept of Ecosystem Services in the Millennium Ecosystem Assessment (2005)

Prepared by the STFC based on Reference[7~9]

Provisioning Services Provide goods that directly benefit humans. Often have clear monetary value. Includes timber and medicinal plants from forests, fish from seas, rivers, lakes and marshes, etc.
Regulating Services Climate regulation by controlling carbon storage and local rainfall, pollutant removal by filtering air and water, protection from natural disasters such as landslides and strong coastal storms, etc.
Cultural Services Scenery and coastal beauty that attracts tourists, psychological value assigned to certain ecosystems such as holy forests, etc.
Supporting Services Do not provide direct benefits to humans, but are essential for ecosystem functions and indirectly support all other services. Includes soil formation, vegetation growth processes etc.

Figure 2 : Ecosystem Service Functions

Prepared by the STFC based on Reference[7~9] biodiversity and conserving ecosystems contribute to the sustainable use of ecosystem services. Although the main point of discussion in this paper is the conservation of ecosystem services (this paper's main theme) and the ecosystem functions that create them, this paper will use phrases such as "conservation of biodiversity" with, as necessary, descriptions concerning references cited, since this sort of expression is gradually penetrating into society more (see Chapter 1).

2-2 Value of Ecosystem Services

In recent years, researchers have been testing ways of quantitatively calculating the value of ecosystem services. A joint report entitled "The Economics of Ecosystems and Biodiversity" (TEEB) was released at the 10th Conference of the Parties to the Convention on Biodiversity (COP10) held in Nagoya in October 2010.[10] The study employed an economic approach to analyzing the value and effects of ecosystems and biodiversity and the report is regarded as similar to the earlier Stern Review that addressed global warming's effects on society in terms of economic loss. The report presents examples concerning the quantitative value of ecosystem services such as the following.

- The economic benefit of preventing greenhouse gas emissions through forest conservation: US$3.7 trillion
- The economic loss of decreasing fishery resources: US$50 billion a year
- The output of pollinated fruit and honey from bees: US$200 million (Switzerland only)
- The market size of nature-dependent industries: US$5 billion annual increase in natural foods and beverages; 20% annual increase in ecotourism (est.)

For example, the news that the sudden drop in the global bee population damaged fruit farmer's production is fresh in our mind.

This is how the discussion has turned to how connected ecosystem services are to our lives and what the quantitative value of ecosystem services is. "Biodiversity and business" is an especially important agenda item in discussions on conserving biodiversity and ecosystems. This conversation is based on the argument that ecosystem services' interconnection with industry and business activities is far-reaching.

2-3 Overview of Corporate Awareness and Action

Figure 3 is an extraction of results concerning corporate awareness and action for global warming prevention and biodiversity conservation from the survey on Environmentally Friendly Corporate Behaviors (most recently released in December 2010[10]) that the Ministry of the Environment has carried out since 1991. Responses on what place global warming prevention and biodiversity conservation have in corporate policy and business are shown chronologically. The number responding that they have "implemented measures" for global warming (the sum of ① and ②) has increased each year, reaching

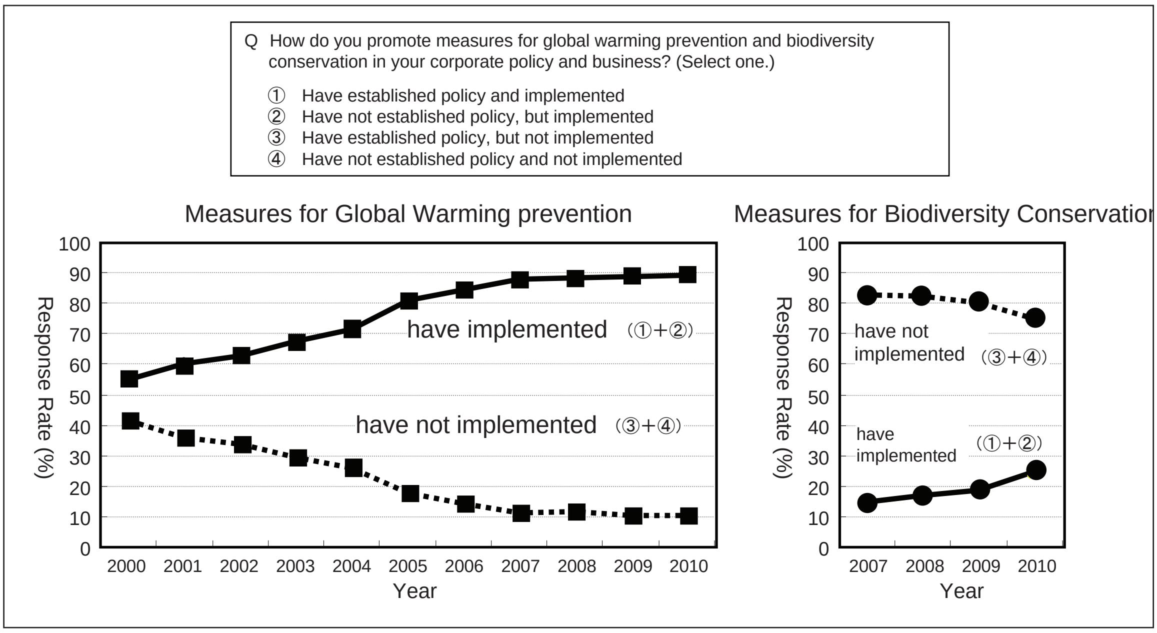

Figure 3 : Corporate Promotions on Global Warming and Biodiversity Conservation (MOE Survey Results)

Prepared by the STFC based on Reference[11]

89% in 2010. Meanwhile, the number responding that they have "not implemented measures" to conserve biodiversity (the sum of ③ and ④) was still 75% in 2010, demonstrating a large gap between these and action to prevent global warming.

Figure 4 shows that the reason for this is that 66% of companies answered that biodiversity conservation "is not closely related to business activity (③)" We can interpret this to mean that action to conserve biodiversity is not very necessary for their business.

2-4 Obscure Relationship between Corporate Behavior and Ecosystem Services

As shown by Figures 3 and 4, the reason why companies split into two groups who do and do not place importance on biodiversity conservation is likely a difference in how far each company recognizes the extent of their responsibility for their corporate behavior. As an example, a company in the middle of the supply chain shown in Figure 5 that engages in "production, manufacturing, sales" often does not supply materials as upstream companies do or dispose of waste as downstream companies do. These tasks are usually performed by other companies in completely different industries. Such companies probably do not recognize a responsibility spanning the entire supply chain. Instead they would consider it the responsibility of other companies and industries that are directly connected to the ecosystem services corresponding to the upstream and downstream processes. This is why

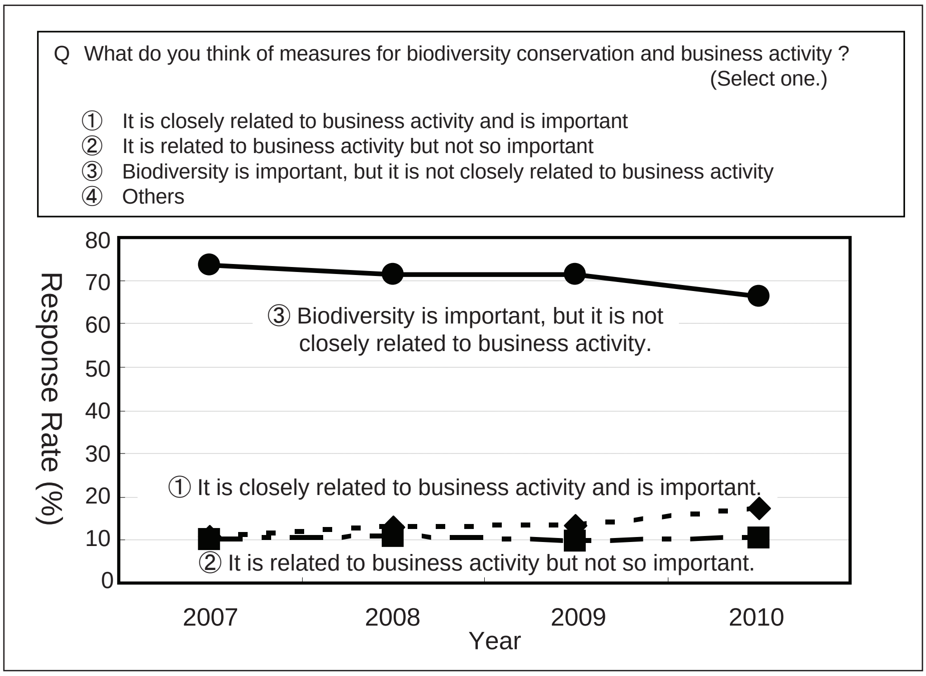

Figure 4 : Corporate Concern for Biodiversity Conservation (MOE Survey Results)

Prepared by the STFC based on Reference[11]

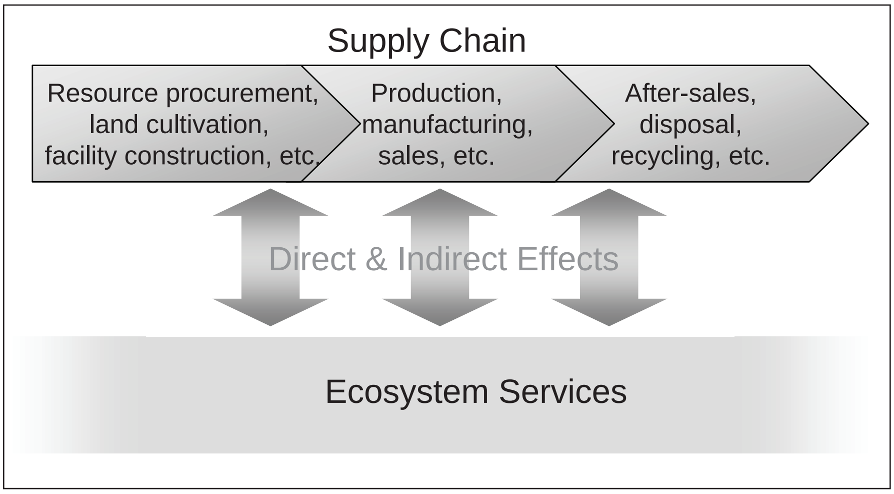

Figure 5 : Relationship between Business Supply Chains and Ecosystem Services

Prepared by the STFC

it is more difficult to feel the need for one's company to take action to conserve biodiversity and recognize that the company is connected to ecosystem services.

Meanwhile, it is also difficult to say that companies have a broad understanding of what they exactly should do to conserve biodiversity. In the case of combating global warming, "reducing greenhouse gases = reducing CO_2 = saving energy" is a relatively easy concept to understand. If the company takes action to conserve energy, then that will become its benefit by cutting costs. However, in many cases the company perceives no direct benefits, while targets of ecosystem conservation is connected with extensive human benefits as shown in Figures 1 and 2.

In consideration of the above, the main factor for why ecosystem and biodiversity conservation have not made advances in corporate behavior is probably that the relationship between corporate behavior and ecosystem services is difficult to recognize. Accordingly, an important task at hand is to establish the general tools or indicators that provide an overview of this relationship.

The following chapter provides examples of methods and schemes that have been tried out to resolve this issue.

3 Activities on Corporate Ecosystem Conservation

3-1 Examples of Recent Action

The following methods have been established to assess the impact on nature by business activity.

- Environmental impact assessments: LCA
- Environmental performance assessments: LEED, CASBEE, etc.
- Habitat assessments: HEP, JHEP, etc.

The above methods can be used to assess the impact of specific business operation processes –such as facility construction or land cultivation that an operation entails – on an ecosystem service. However, there is no exhaustive assessment approach anywhere in the world that can cover business activities in their entirety.

In March 2008, the World Business Council for Sustainable Development (WBCSD), the Meridian Institute, the World Resources Institute (WRI) and others published "The Corporate Ecosystem Services Review," which proposed the Ecosystem Services Review (ESR) as a way to approach assessments of the relationship between business activity and ecosystem services in terms of both dependence and impact.[12] Since then, much corporate action today seeks to find solutions based on ESR frameworks. The following section gives examples of assessment frameworks observed in corporate business processes.

3-1-1 Framework Example: Supply Chain-Based Impact Assessment Index

Fujitsu Limited is developing a framework to view the impact on ecosystem services based on its supply chain and products including land used for the business (see Figure 6). The company identified the components that impact ecosystem services by using existing an environmental impact assessment method (LCA) and habitat assessment (HEP) to calculate the impact level, and formulated an integrated index for the entire Fujitsu Group. Since ICT is the Fujitsu Group's major business, ICT technologies into gathering, analyzing, evaluating, managing and monitoring the necessary data for biodiversity conservation is investigating to apply on the integrated index.

3-1-2 Framework Example: Relationship between Business Life Cycle and Ecosystem Services

Accor Group, a French hotel operator active in ninety countries, formulated guidelines for the sustainable use of biological resources in terms of its hotel business life cycle (see Figure 7). The guideline considers conservation activities from long term view; planning phase in land use for hotel, construction phase of hotel gardens, operational phase such as sightseeing and hotel food ingredients, and even closing phase of hotel business. Accor has been implementing sixty-five conservation items based on eight topics including water, energy, the ozone layer and biodiversity since they introduced the Hotel Environment Charter in 1998. As of 2007, 3,900 hotels (84% of whole Accor hotels) are taking action based on this charter.

3-2 Guidelines Encouraging Corporate Conservation

In April 2011, the WBCSD released, in the form of a report, the Corporate Ecosystem Valuation to further assess the relationship between business activities and ecosystem services, in order to promote ESR

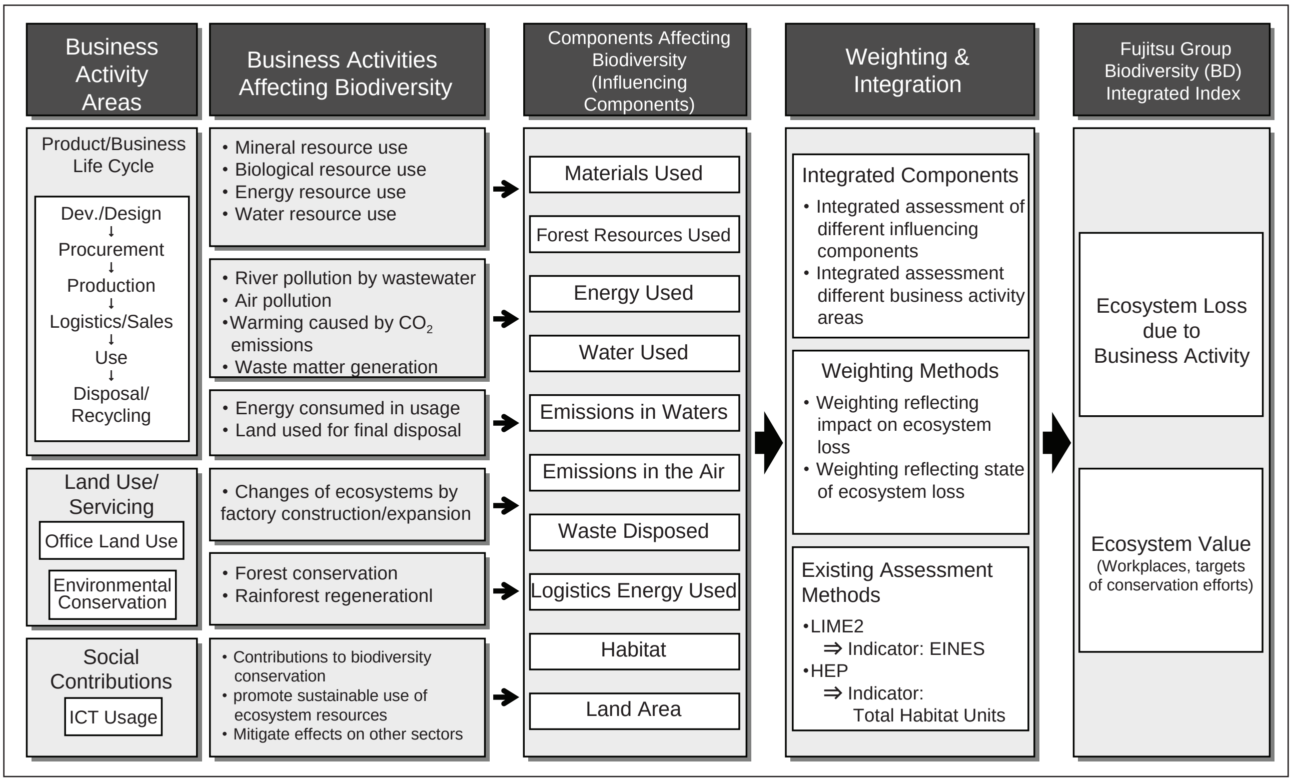

Figure 6 : Fujitsu Group Framework (Example)

Prepared by the STFC based on Reference[13]

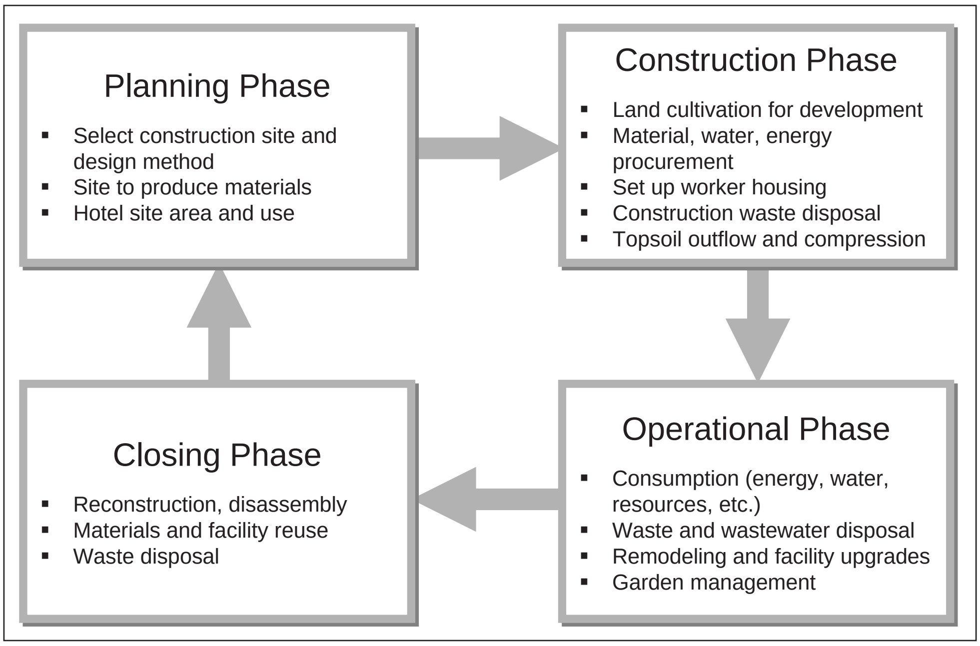

Figure 7 : Hotel Business Framework (Example)

Prepared by the STFC based on Reference[14]

(as proposed in March 2008).[15] The report provides detailed descriptions of the CEV method and steps to execute it. A notable point in the document is that the correlation, which is analized with dependency and impact of industry on ecosystem services for five industries, is indicated on a framework consisting of an industrial sector/ecosystem services matrix (see Figure 8). As many companies and businesses fit within these five industrial sectors, those involved in starting up conservation activities can recognize the macro-relationships between business activities and ecosystem services. However, a more detailed examination requires reference to preceding cases as shown in Section 3-1.

The correlation in Figure 8 shows that all five industrial sectors depend on ecosystem services somewhat and have an impact on them. Considering that the matrix covers not just single businesses but entire supply chains, including upstream and downstream processes, it signifies that these interconnections appear between various corporate activities and ecosystem services (see Section 2-2).

Green industries such as organic farming and ecotourism are industrial sectors that are particularly highly dependent upon ecosystem services. On the other hand, primary industries such as fishery, agriculture and forestry, and financial service industries such as banking and insurance, have an especially large impact on ecosystem services.

3-3 Corporate Promotion of Ecosystem Conservation in Global Supply Chains

British-Dutch company Unilever, which sells a vast array of foods, detergents and other daily necessities across the globe, announced a vision to “double the size of our business while reducing our overall environmental impact across our entire value chain.” The company is proactively developing a biodiversity conservation certification system to promote ecosystem conservation through Unilever's main products.[16] Many of the products the company handles are dependent upon ecosystem services, and one of its defining characteristics in particular is that many of its raw materials are supplied by agriculture. Unilever, which were facing problems such as rainforest destruction by one of its traditional suppliers, palm tree orchards, formulated its own Sustainable Agricultural Practice Guidelines (now known as the Unilever Sustainable Agriculture Code) in the latter half of the 1990s. Since 2002, the company has put the guidelines into practice for five grain species and has worked to expand its certification system throughout the industry. Below are some typical raw materials involved in the certification system Unilever established (see Chapter 4 for certification system details).

(1) Palm Oil

Unilever, a founding member of the Roundtable on Sustainable Palm Oil (RSPO)[17] established in 2004, has pulled the general industry along in a transition to sustainable palm oil. In 2009, Unilever makes 15% of purchases from producers with the company’s GreenPalm certificates. Unilever has set the goal of having 100% of its palm oil supplied by producers employing sustainable farming methods by 2015.

Ecosystem Services (Excl. supporting services) (Examples)		Biodiversity dependent industries (fishing, agriculture, forestry)		Large "footprint" industries (mining, oil and gas, construction)		Manufacturing & processing (chemicals, ICT, consumer products)		"Green" enterprises (organic farming, ecotourism)		Financial services (banking, insurance & other financial intermediaries)	
		Depend	Impact	Depend	Impact	Depend	Impact	Depend	Impact	Depend	Impact
Provisioning Services	Food	●	●	○	●	●	●	●	○	●	●
	Timber & fibers	●	●	●	●	●	●	●	○	●	●
	Freshwater	●	●	●	●	●	●	●	○	●	●
	Genetic/ Pharmaceutical resources	●	●	○	○	●	●	●	○	●	●
Regulating Services	Climate & air quality regulation	●	●	●	●	●	●	●	○	●	●
	Water regulation & purification	●	●	●	●	●	●	●	○	●	●
	Pollination	●	●	–	○	○	○	●	●	●	●
	Natural hazard regulation	●	●	●	○	●	○	●	○	●	●
Cultural Services	Recreation & tourism	○	●	–	●	–	○	●	●	●	●
	Aesthetic/ non-use values	○	●	–	●	–	○	●	●	○	●
	Spiritual values	○	●	–	●	–	○	●	●	○	●

●: Moderate to Major relevance ○: Minor relevance –: Not relevant

Figure 8 : Analysis of Correlation between Industrial Sectors and Ecosystem Services (from WBCSD-CEV)

Prepared by the STFC based on Reference[15]

(2) Tea

In 2009, Unilever purchases 15% of its black tea from Rainforest Alliance (RA) Certified[18] tea farms. The company has set the goal of having 100% of its black tea for teabags supplied by tea farms employing sustainable farming methods by 2015.

(3) Seafood

In 1996, Unilever partnered with the World Wildlife Fund (WWF) to establish the Marine Stewardship Council (MSC)[19] and began certifying seafood.

4 Certification Systems to Promote Ecosystem Conservation in Supply Chains

4-1 Distribution of Ecosystem-Friendly Certified Products

As explained by the examples in Section 3-3, distribution of certified products is an effective means to promote ecosystem conservation in global supply chains by utilizing market mechanisms (see Figure 9). This approach is based on the products with certification label qualified by conservation activities for biodiversity and ecosystems, and is also utilized as part of a company's marketing or corporate social responsibility (CSR). Figure 9 is the case applied with a particularly strong connection to ecosystem services in the upstream processes from Figure 5. In current certification systems, method of ecosystem conservation implemented when delivering resources in upstream processes is general.

The basic concepts of a certification system are as below.

1. Certification labels are given for ecosystem-friendly products that are qualified with an assessment/certification by an examining authority to judge whether the products meet criteria prescribed by a third-party certification body.
2. Consumers understand that a certification label shows a good product for the environment or ecosystems and selectively purchase certified products.
3. Expanding sales volume of products encourages ecosystem conservation relevant to ecosystem service functions.

Furthermore, since certified products also provide traceability from upstream to the downstream processes, they have been regarded as safer products recently, thus their added value is increasing.

The main industries in which certification systems are spreading at present are the primary industries of forestry, fishery and agriculture. Figure 10 shows typical examples of certification labels and certification organizations.

(1) Forestry

The Forest Stewardship Council (FSC)[20] was founded in 1993 by international NGOs and companies involved in forestry with the purpose of solving deforestation problems and increasing the economic and social value of forests. FSC-certified products are distributed worldwide on an extremely large scale and are very well known. It has become a

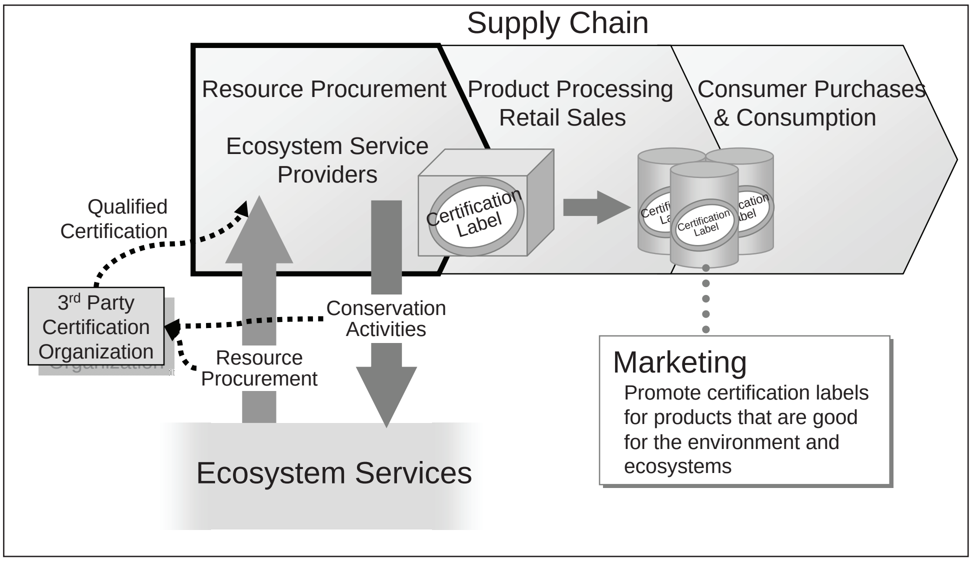

Figure 9 : Market Mechanism-based Ecosystem Conservation Methods

Prepared by the STFC

model for many other certification bodies and systems established later. The Sustainable Green Ecosystem Council (SGEC)[21] is a Japanese organization that gives certifications based on the state of domestic forests.

(2) Fishery

The MSC is a seafood certification body established in 1996 by Unilever and the WWF (see Section 3-3), said to be done with the FSC model. There exist over 5,000 products worldwide carrying the MSC certification label. Marine Eco-Label (MEL) Japan22 is an organization promoted by the Japan Fisheries Association certifying seafood products that are good for Japanese marine resources and ecosystems.

(3) Agriculture

The RA is a certification body established in 1987 to protect the rights and social conditions of agricultural labor and local communities, in addition to ecosystem conservation by the agricultural industry. The RA-certified products totally include more than just products, it has also certified 640,000 hectares of forest, 690,000 hectares of small, family-run farms, as well as associations and plantations in more than 70 countries.

This is how international certification systems in the forestry, fishing and agriculture industries have spread and become models for others. .These systems will likely expand further to new regions, countries and economic zone. However, internationally uniformed certification standards do not necessarily suit the conditions and customs in every country. Certification systems require glocalization to follow international certification criteria that make up the de facto standard while adapting to the circumstances of each country. Meanwhile, we must avoid creating excessive kinds of certification labels so that consumers will not confuse.

4-2 Certification Systems to be improved in the future

4-2-1 Industrial Product Applications

Manufactured product seems to be typical area where certification systems have not advanced yet regardless of the widespread use

There are various stages in the lifecycle of an industrial product that affect the environment in many ways: material mining/delivery (upstream processes), production, sales and disposal (downstream processes). The Life Cycle Assessment (LCA), an environmental impact assessment method developed to quantitatively and objectively calculate future environmental impact, is a general-purpose tool that is also an international standard as ISO 14040-14043. One can use this method to calculate things such as utilization efficiency of energy, resources and materials and the impact of substances released over the entire life

Industry	Certification label	Certification organization name	Certification base
Forestry	FSC	Forest Stewardship Council 20)	World
	SGEC	Sustainable Green Ecosystem Council 21)	Japan
	SFI	The Sustainable Forestry Initiative 24)	USA
	CSA-SFM	The Canadian Standards Association - Sustainable Forest Management 25)	Canada
	PEFC	Programme for the Endorsement of Forest Certification Schemes 26)	Europe
Fishery	MSC	Marine Stewardship Council 19)	World
	ASC	Aquaculture Stewardship Council 23)	World
	MEL Japan	Marine Eco-Label Japan 22)	Japan
Agriculture	RA	Rainforest Alliance 18)	World
	Good Inside	Good Inside 27)	World
	4C	Common Code for the Coffee Community Association 28)	World
	RSPO	Roundtable on Sustainable Palm Oil 17)	World
	RTRS (Preparatory phase)	Round Table on Responsible Soy Association 29)	World

Figure 10 : Certification Labels and Certification Organizations (Examples)Methods

Prepared by the STFC based on Reference[17~29] cycle into the atmosphere, water and soil. It can also be used to acquire a product's environmental impact certification from a third-party organization.

In an environmental impact assessment using the LCA method, the atmosphere, water and soil in particular are ecosystem services categorized as regulating or support services (see Figure 2). Accordingly, using the LCA method to reduce manufactures' environmental impact level consequently leads to ecosystem conservation. Applying LCA method into CEV method have implemented as one means of executing the CEV method of evaluating the relationship between business activity and ecosystem services (see Figure 8). However, this integration is not simple and common. It is expected that this methodology improvement enables manufactures to add certification conservating biodiversity and ecosystem. It is also expected that systemization based on ecosystem conservation index so that consumers will not confuse with CO_2 footprint. In order to establish comprehensive evaluation method combined with LCA method and CEV method, immediate methodology development is required by gathering various experts on LCA, ecosystem conservation and biodiversity conservation from academia and research institute. Of course, it is essential to train experts versed in the LCA and CEV methods, as well as detailed information on inventory (assessed items) and simulation logic. Industrial organizations and other key players involved with manufactured goods need to promote investigative projects while training experts.

4-2-2 Service Industry Applications

It is conceivable that the service industry, which handles the sale of various products, could provide packaged certification services that are good for conserving biodiversity and ecosystem conservation. For example, the restaurant store offering menus used at least a certain amount of existing certified distributed products (agricultural produce, seafood, etc.), is qualified with "ecosystem conservation-certified service store" certification label. Consumers get a new channel for purchasing value-added services from service industry businesses In addition to the existing distribution channels by which stores purchase certified products. Popularizing certified products, this could spread to even more diverse consumer segments because of knowing and remembering the significance of many different products with certified labels in each industry, they could just remember one packaged certification service. A clear example is the hotel service discussed in Sub-Section 3-1-2. Packaged certification services could be an area of growth, having the potential to become a new guarantee of safety and a contributor to stimulating the primary, secondary and tertiary sectors of the economy.

When setting up certification systems such as packaged services that bring benefits on a wide range of stakeholders, it is preferable for industry groups and academic societies to implement referencing international NGO's past experiences. In the hotel business, for example, proposing concrete projects to examine would be basic roles for industry groups and academic societies

Moreover, it is particularly effective in packaged services, including the industrial product applications discussed in Sub-Section 4-2-1, for economic experts with specialties such as market structure analysis, business analysis and environmental management to clarify the social external costs (the social costs that cannot be resolved by market mechanisms) and benefits on ecosystem conservation due to ecosystem services based on market mechanisms.

The role of the media is also important for promoting discussion on ecosystem services and for encouraging social participation for the sake of popularization and raising public awareness.

5 Conclusion

This paper has explained the concept of ecosystem services and presented examples of certification systems as one effective means of sustaining them. Market mechanisms within daily consumption, by which companies on the supply side provide certification systems for biodiversity and ecosystem conservation and consumers on the demand side selectively purchase those certified products, are an extremely effective way to foster awareness in the form of active participation in conservation throughout society, in addition to the rapid global spread of conservation. Japan in particular, which is heavily dependent on the overseas provision of many daily necessities such as food, at the same time imports many ecosystem services. Thus, we need an international perspective of our responsibility to conserve ecosystems on a global level.

According to the results of “The 9th Science and Technology Foresight – Contribution of Science and Technology to Future Society – The 9th Delphi Survey” executed by NISTEP, a “comprehensive landscape evaluation taking the value of biodiversity into account during the environment assessment process” is predicted by 2025, and “market economy methods including mitigation banking (biodiversity offset banking) that offsets the environmental load on urban areas by the rehabilitation and maintenance of natural resources in rural areas” by 2026.30 Contributing to conserving the Earth’s environment and ecosystems will probably be one of many restraints on humanity in the foreseeable future.

Another thing that ecosystem conservation certification labels correspond to traceability requirements for more secure society. An advanced global market model in regions and economic zone actively embraced certification systems, is the image of future vigorous society. In the service industry sectors with high added value including manufactures that are Japan's advantage, encouraging certification distribution leads to realize next-generation environmentally-friendly market mechanisms. It is expected that companies that have not addressed the relevance of ecosystems much before, as well as government agencies, take actions and efforts forward-looking as described in this paper.

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4

Globalization and the Intensification of Global Competition Seen in the IEEE: What Impact will International Mobility of Research Personnel have on R&D? Symposium Report

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1 Symposium Overview

The National Institute of Science and Technology Policy's Science and Technology Foresight Center, in considering the international competitiveness of Japan in the future, chose IEEE (the Institute of Electrical and Electronics Engineering, Inc.), one of the largest international societies, as the target for a variety of analyses. The data acquired led to a number of discussions intended to help clarify the current circumstances surrounding engineering R&D both in Japan and around the world.[1] In March 2010, the first symposium was held, and discussions focused on the field specificity of Japanese R&D and the impact of human movement, among other things. This time, at the second symposium, we discussed in detail recent changes relating to the IEEE and analysis results on the international mobility of researchers. We also discussed their relationship and the impact they will have on the future.

This time, the Science and Technology Foresight Center announced that the symposium was to be divided into two halves. The first half consists of two presentations, (1) "The State of Japanese and Worldwide R&D as Inferred from Analyses of IEEE Conferences and Periodicals" and (2) "A Comparison of International Mobility of Researchers in Three Fields."

The second half of the symposium, based on the contents presented in the first half, featured a discussion involving all in attendance. In an attempt to keep the discussion lively, four commentators were established in hopes of focusing the comments received. Serving in the capacity of commentator from the perspectives of engineering research and university administration was Dr. Fumio Harashima (IEEE Life Fellow, President of Tokyo Metropolitan University). Serving from the perspectives of organizational management and abilities was Dr. Kiyonori Sakakibara (Professor, Hosei Graduate School of Innovation Management, Hosei University). Serving from the perspectives of international competitiveness of industry and its influence was Dr. Hiroyuki Chuma (Professor, Hitotsubashi Institute of Innovation). Finally, serving from the perspectives of the future possibilities of Asian scientific/technological innovations was Dr. Atsushi Sunami (Associate Professor, National Graduate Institute for Policy Studies). A total of 45 individuals participated in this symposium.

In the chapters below, chapter 2 summarizes the analysis results that were presented and exhibited during the first half of the symposium, while chapter 3 highlights the majority opinions from among the many opinions presented during the discussions in the second half of the symposium and concludes with perspectives on what should be studied in the future. Especially problematic data as well as all of the additional opinions raised will be published as an appendix to this document.

2 The Present State of Diversity and Mobility in Japanese Engineering R&D

2-1 Japan and Trends in World Research (Presentation 1)

First, a presentation on trends in world research and Japan's place within it was made based on reference data.[1] As mentioned above, a continuous literature survey was conducted targeting IEEE periodicals at the National Institute of Science and Technology Policy, and the reference data[1] becomes the third of a series of reports. With the addition of new conferences/proceedings (international conference proceedings), this survey, which targets IEEE periodicals for analysis, produced and analyzed data from over 1.5 million pieces of engineering literature over a period of 30 years.

The main contents were as follows.

- It is clear that, in recent years, research has increased around the world, particular in the field of information and communications. As of yet, the United States is the country pioneering new fields of study and is the leader in world research. However, if judging only by conferences, China has been surging at an incredible pace, and as of 2008, the number of Chinese proceeding articles overtook that of the United States, making them #1 in the world (Appendix Figure 3).
- With the world trending the way it is, Japan has shown a very peculiar transition. While it has done fine in regard to the number of proceeding articles, preserving its #3 ranking behind the United States, it has leveled-off over the last 20 years in terms of periodicals, with its rank continuing to drop gradually (Appendix Figure 2, 3). With regard to articles per field, many dealt with electricity and few with information as Japan continues its divergence away from the rest of the world's research.
- The world's electrical, electronics, and information and communications-related research is polarized into three regions: North America, Europe, and East Asia (China, Taiwan, Korea, Japan, and Singapore). Japan, once an overwhelming #2 in the world for periodicals, is currently just one among East Asian countries.
- In Japan, universities take on a leading role in the production of literature, and substantial growth has been observed at universities in Japan. However, when examined by field, the number of fields has remained fixed for a long time, with Japan stuck on its own path, continuing its divergence away from the rest of the world. Also, only the amount of conference literature has been increasing rapidly. No growth trends have been observed as far as articles in periodicals are concerned. (Appendix Figure 3-5).
- An examination of the main companies producing literature reveals subjects like project reorganization and strategic international expansion of R&D. For example, Japan seeks information and communications research from overseas companies to make up for its own shortcomings in the field. The fear, however, is the fact that a source of new research fields and R&D has not materialized from within Japan.

2-2 International Mobility of Researchers (Presentation2)

Continuing on, analysis results on the international mobility of researchers were announced based on the reference material.[2] In the reference material,[2] international mobility of researchers was analyzed based on the home country/organization of researchers who have all three university degrees (undergraduate, graduate, and doctorate) and their relationship to organizations affiliated with the timing of the latest article presentations. The three fields chosen for analysis were "robotics," a next generation industry where application is expanding, "computer vision," which has given birth to a number of venture companies rooted in the research results of image recognition, and "electronic devices," a field of research that supports the electronics industry. From representative academic periodicals chosen for their large scientific impact on these three fields, historical data on articles and authors representing approximately 2,300 individuals per field for a total of 7,000 individuals was drawn up and a concrete international mobility shown.

- The field of robotics
  The majority of the world's universities, in addition to accepting researchers, are also sending them overseas in great numbers. In the other two fields, the accepting and supplying organizations were separate, but in this field, they were almost completely the same. In Japan, the number of researchers affiliated with the University of Tokyo was top in the world, though moves overseas have rarely been seen.
- The field of computer vision
  Chinese organizations provide a large number of researchers to the world. Tsinghua University and the Chinese Academy of Sciences are the typical examples. Also, universities and businesses are accepting overseas researchers. For universities, United States, United Kingdom, Singapore, and Hong Kong all stood out for their acceptance of overseas researchers. For businesses, Microsoft

accepted a great number of researchers who were educated overseas.

- The field of electronic devices

  Besides universities, international research institutes and companies have been accepting many researchers. Typical examples of research institutions include IMEC (Belgium) and MINATEC (France). Typical examples of companies include NXP/STMicroelectronics (Europe), TSMC (Taiwan), IBM (USA), and Samsung (Korea).

  In Japan, there are many researchers at both companies and universities, but there is virtually no mobility. Also, while there are a large number of researchers affiliated with Japanese companies, the companies have not been accepting researchers educated overseas. Both international mobility and domestic mobility were low for Japanese universities (Appendix Figure 6-8).

- Overall characteristics of Japan

  No matter the field, Japan exhibited little movement of researchers compared to other countries. Robotics and electronic devices are fields where Japan is highly competitive internationally, with the second most researchers after the United States, but the amount of movement taking place is low when compared to other countries. Japanese universities, when compared to major universities around the world, tend to be lower in terms of mobility between domestic organizations than is the case in other countries. Particularly in robotics, the number of researchers working at their alma mater is high (Appendix Figure 6-8).

3 Discussion (from the contents of the second half)

Below are the majority opinions taken from among all of the opinions raised during the discussion.

Presentation 1, which dealt with international competitiveness, showed that although the volume of conference article has been rising, the number of periodicals has remained stagnant for a long time. Company researchers appear to be transferring to universities to work on the same research they engaged in previously. Also, the specialization of university research into particular fields, couple with a lack of diversity, is viewed as problematic. Speculating on the main reason for all of this, fears have been raised that the fact that attendance of conferences is not translating into articles in periodicals means either that there is a decrease in quality at the research level, that researchers are unable to endure the mental strain of the article-creation process, or that researchers tend to present a Japanese article following the conference and end the process there. Additionally, it has been pointed out that phenomena that appears to be viewed as problematic in an engineering sense, also appears to be viewed as problematic in an economic sense. With regard to the lack of diversity seen in research activities, research subjects are fixed, and one opinion raised was that the isolated nature of universities might be part of the problem. There were also concerns for the future that the plateau in research could turn into a decline and pessimistic conjecture that the weakening of research activities could continue.

In presentation 2, which dealt with mobility, when compared to the increase in mobility of foreign countries, an active flow of researchers was not observed in any of the three fields in Japan, and the fact that researchers in all three fields tend to stay in Japanese organizations was viewed as problematic. As for a cause, it was mentioned that, at a time when researchers around the world started to move freely, only Japan was left behind. It was pointed out that, although there has been a trend around the world where a particular person triggers accelerated mobility among other researchers, that sort of thing has not happened in Japan.

A comprehensive look at both presentations suggested the following points as potential targets for study in the future.

● The need for a mechanism that ensures diversity

- A society without diversity cannot progress. Other advanced nations can cover for a lack of ability in engineering with their diversity. Therefore, there is a desire for a mechanism that ensures diversity.

● Changes are needed for Japanese scholarly societies

- Referencing the scholarly society of IEEE from an administrative/business-oriented perspective, some of the things the society does best include providing direction by way of ambitious goal setting and serving as a place for the exchange of ideas. Japanese scholarly societies need to change and adopting some of the things other societies do well might be a good start.

● The importance of providing meta-information

- Meta information mainly refers to “upping the

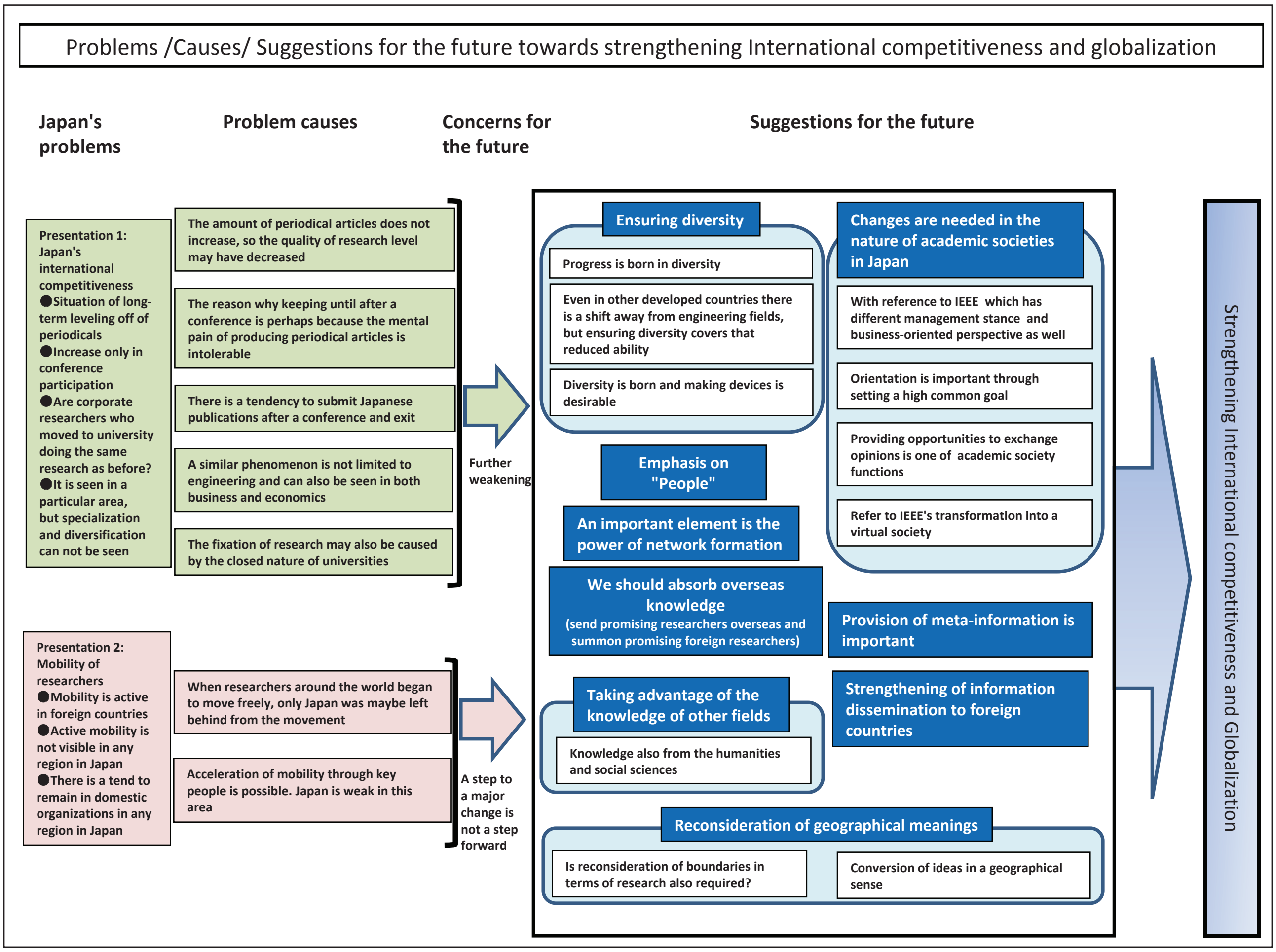

Figure 1 : Problems Causes, Concerns and Suggestions derived from opinions

appearance of the activities you're engaged in a notch as if in response to being watched by third parties" and "raising the level of abstraction of the significance/meaning of research results to make them more accessible to a greater number of individuals." When we are acutely aware of moving toward a period going through complex changes, this dispatch/provision is important for us to respond to these changes as quickly as they come. In particular, this sort of meta-information dispatch/provision needs to be among the changes made to scholarly societies.

● Stressing the importance of "people"
- In Japan, there is a lack of thought put into just how to use each individual person. It is important that Japan aim for development that is focused on the individual.

● Network creation an important factor
- If we improve/strengthen our networking, we may also be able to cover for Japan's current status as a country with low researcher mobility. In that case, creative abilities concerned with the way in which we construct networks will become increasingly important in the future.

● We should absorb foreign knowledge
- To absorb more foreign knowledge, we should send young and promising researchers overseas and also summon promising foreigners to Japan.

● Utilizing the wisdom of other fields
- We are gradually encountering large changes that cannot be solved by the fields of scientists and engineers alone (and will encounter more in the future). We should utilize the wisdom of experts versed in the humanities and social sciences to overcome these changes.

● In addition, opinions were raised that Japan may need to intensify its transmission of information overseas and reconsider its geographic significance.

The causes of problems, concerns, suggestions for the future, perspectives that should be taken seriously, and other contents relating to a variety of opinions raised in the discussion above have been compiled and are shown in Figure 1.

4 In Closing

A symposium was held based on “Globalization and the Intensification of Global Competition Seen in the IEEE.” Through a discussion based on the contents of the concrete data that was presented, existing problems and their backgrounds were identified and perspectives on studies needed for future improvement were shown (Figure 1). However, there are limits to these in the forms of limited sources of information and a limited number of participants from which to draw opinions. In the future, I believe that these perspectives will need to be scrutinized, missing perspectives provided for, and studies dug into deeper. I also believe more discussion on concrete proposals is needed. It is my hope that the materials I have provided here will be of help to future studies.

Acknowledgments

Starting with President Fumio Harashima of Tokyo Metropolitan University, Professor Kiyonori Sakakibara of Hosei Graduate School of Innovation Management at Hosei University, Professor Hiroyuki Chuma of the Hitotsubashi Institute of Innovation, and Associate Professor Atsushi Sunami of the National Graduate Institute for Policy Studies for graciously agreeing to serve as commentators during the symposium, I would like to express my profound gratitude to all participants who presented invaluable opinions and comments and took time out from their busy schedules to attend and contribute to this symposium.

Appendix: Discussion Contents

The contents of the symposium's discussion are shown below. This section is divided into opinions concerning the causes of problems, concerns for the future, and suggestions for the future, among other things, and combines similar opinions to display them as one. Furthermore, with regard to each individual opinion, the exact expressions used were maintained whenever possible, though, on the other hand, summaries use focused expressions to capture the gist of the argument.

A) Discussion based on presentation 1: "Japan and Trends in World Research"

(1)Identification of problem areas

Figures 2-5 below were the primary focus of the discussion.

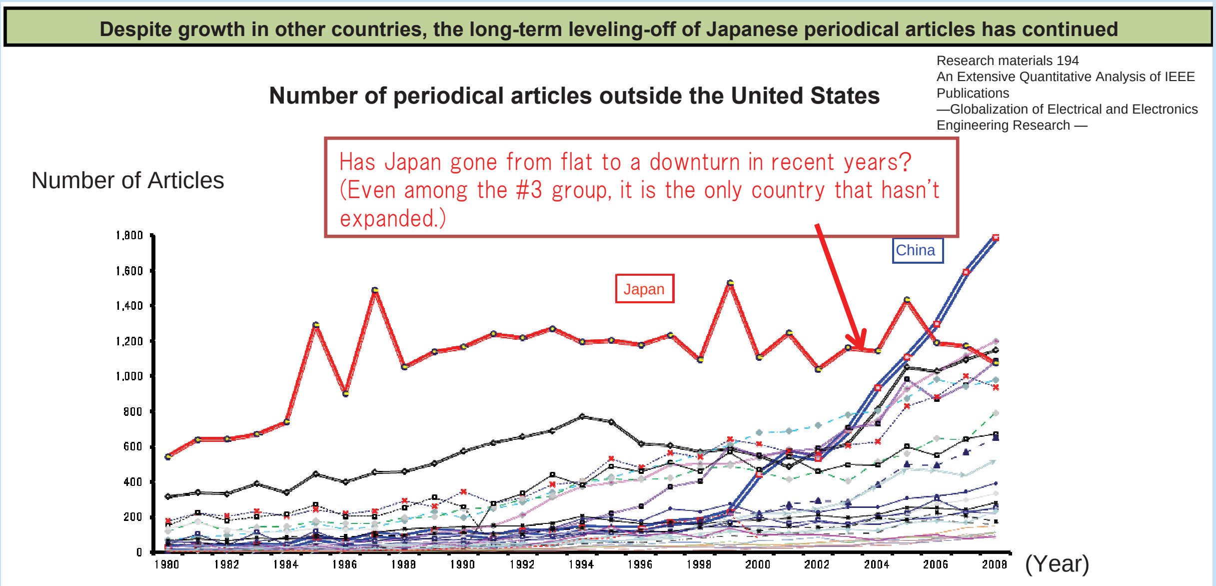

Figure 2 : Long-term leveling off in terms of periodical articles

From Presentation 1/Reference[3]

(2) Discussion issues

The discussion focused on the following issues

1. Long-term leveling off and research field bias has been observed in Japan's engineering R&D. What will happen if things continue like this unabated?
2. Are there other fields/areas where long-term leveling off and field bias has been observed outside of engineering? Or are similar trends occurring outside of R&D?
3. Is the research pattern of Japanese engineering researchers (particularly researchers at universities) on the right track?
4. Assuming there is something concrete that can be done to improve the situation in the future, what do you think that would be?

Shown below is a summary of the opinions raised based on issues 1-4. (Descriptions do not deal with each discussion issue).

The growth in the number of conference articles matches worldwide trends

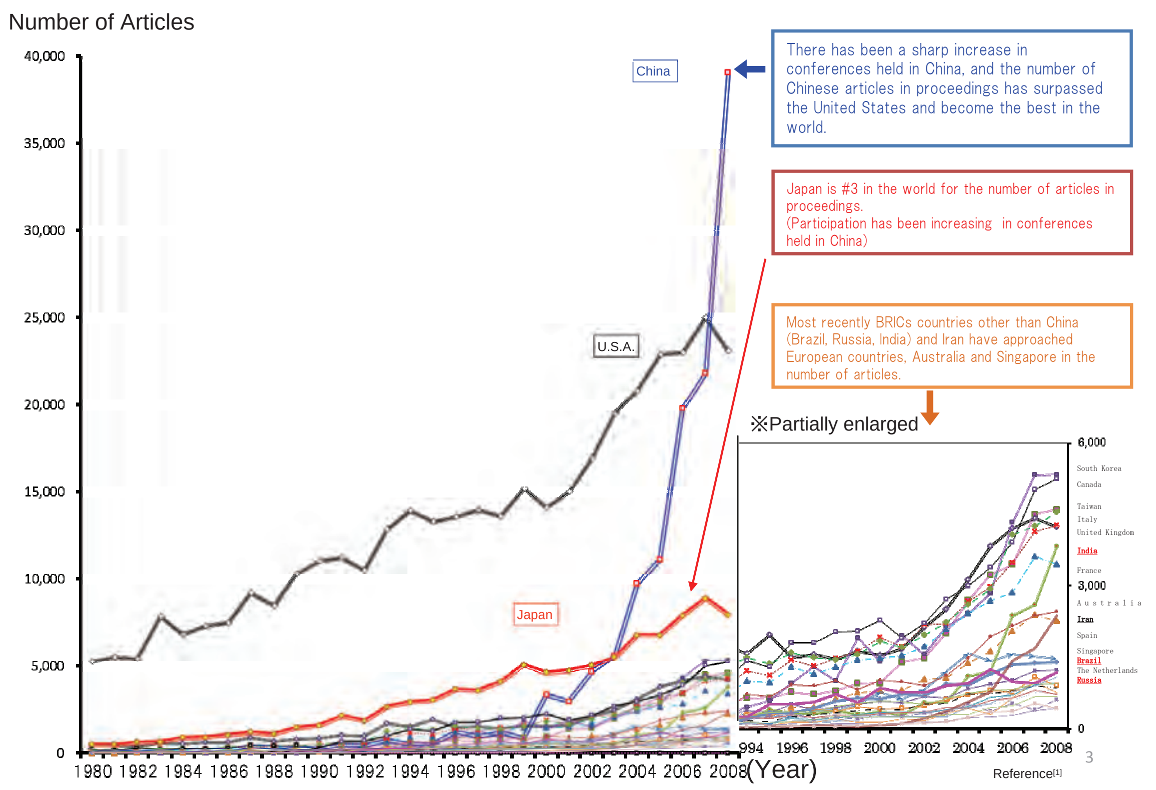

Figure 3 : The growth in the number of Conference articles

From Presentation 1/Reference[3]

Domestic human mobility in Japan from industry to academia has happened, but even if the leader of the periodical production changes, little change can be seen in the contents of the research.

There are fields where corporate researchers have moved to universities and it seems like they have continued the same research

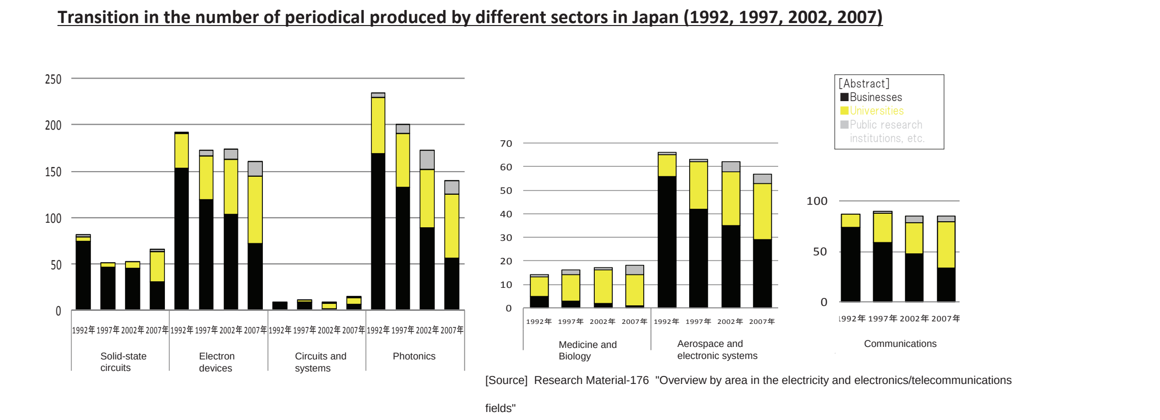

Figure 4 : Replacement of major player in the periodical production and Change of the contents of research

From Presentation 1/Reference[3]

There have been developments in quantitative terms, but on the other hand, diversity has not been seen in university research

- The number of universities producing periodical articles has increased

The number of periodical articles from universities that produced more than five periodical articles

- Reference construction for different research fields in universities
  - On the whole there has been a trend to specialize in a particular field such as superconductivity, but the appearance of diversity of research fields has not been observed.

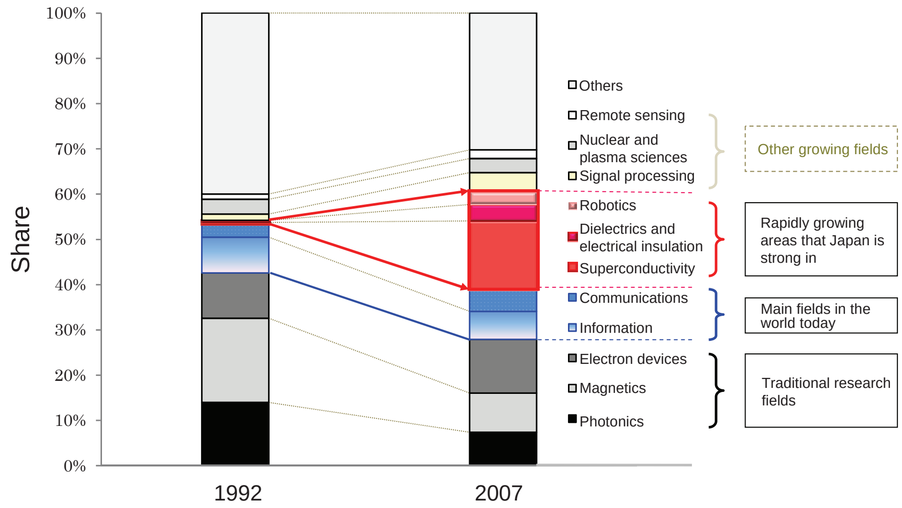

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Figure 5 : Growth in the number of Universities producing periodical articles and trends for specialization in a particular field

From Presentation 1/Reference[3]

(3) Majority opinions concerning the causes of problems

● Electronic conversion, the elimination of the Eastern Bloc, and holding with low-price in China are seen behind the large number of conferences

- Due to the Internet and the process of electronic conversion, holding a conference has become exceeding easy. This trend has also been backed by the increased affordability of airfare, and the fact that the end of the Eastern Bloc has allowed individuals to move much more freely. Finally, the IEEE has been placing importance on conferences that offer high profitability. The reason that there are so many conferences in China might be because they are more profitable, even if membership fees remain the same.

● On whether the lack of increase in Japanese periodical articles is because of a decline in the level of research

- The field of electrical and electronic information has long been on the decline in Japan. The first and foremost cause for this decline is a shift away from engineering, with most of the people in the field already over 40 years of age. While the leaders in this field who are pushing 50 or 60 years old are still highly regarded, there is concern that the quality level of researchers who are researching now has been on the decline. The problem might not be that they are not writing articles but that they cannot write them.

● On whether the halt in action following conferences is a result of the mental strain of the scholarly article process

- Could there perhaps be an increase in the number of researchers unable to endure the mental strain of the process of publishing an article in a periodical following a conference? When an article is written after a conference, it leads to harsh peer reviews and extensive exchanges of information. Moreover, unlike in the past, the Internet makes that exchange process infinitely faster. There is a sense that there are researchers unable to handle this degree of mental strain. The thinking is that it does not necessarily mean a decline in research abilities.

● There is a trend toward ending the process by submitting an article to a Japanese periodical after a conference

- It was pointed out that a reason that there might be an increase in conference appearances without an increase in English articles in periodicals could be that a number of researchers in these fields present their material at international conferences and then go on to only submit their articles to Japanese language periodicals.

● Similar phenomena are not limited to engineering research but are being observed in business and economics as well

- Even with semiconductors, a shift has taken place from customized parts known as ASIC to dual-purpose items like ASSP and FPGA, and this shift will change society in a variety of ways but can easily go unnoticed. In the field of business as well, it is often hard to find the courage to take the next step. Similar phenomena are not limited to just engineering R&D but are being observed all over.

- Certain organizational limits that we have confronted are almost completely like fractal structures to the extent that they cannot be overcome and are phenomena that not only appear in scholarship but in business as well. Phenomena similar to these have even been observed in economics.

- Could there be a cause that goes deeper than just engineering or R&D? It could perhaps have something to do with the characteristics of Japanese citizens.

● On whether the isolated nature of universities is part of the reason for fixed research subjects

- One reason why it is hard for the research subjects in Japan to change could be the isolated nature of universities. For example, if the same professor is at one university for a long time, the subject of his or her research might not change in 20 years. Also, the transfer of researchers to come to universities from companies is viewed positively, but if the former head of a research division at a company comes to a university, the research subject he/she teaches could lead to talk of the past and possibly lower the level of the university in some cases.

● The degeneration of organizations lacking in diversity

- The main cause is a lack of diversity. Without diversity, organizations degenerate. Groups that do not understand diversity and do not respect it are doomed to degenerate.

(4) Another perspective on the background of these problems

● This leveling off may have something to do with pioneering efforts in other fields

- Is the leveling off really a bad thing? If you look at the activities of teachers who hate to get caught up in one field, the number of articles submitted to existing fields by top teachers might be decreasing as those teachers work with students to write the articles necessary to pioneer other fields. Also, it appears that a significant part of their work does not translate into scholarly articles. Accordingly, it is not understood whether or not the decline in the sharing of articles in traditional fields is really a bad thing.

(5) Opinions concerned with fears for the future.

● It is feared that if things continue as is, Japan might not only continue to level off but might actually start to weaken further.

(6) Opinions concerned with suggestions for the future

● The emergence of progress from diversity

- It is impossible for a society without diversity to progress. Progress that occurs within a state of Galapagos Syndrome is not really progress.

● Other developed countries have seen a shift away from engineering but are covering for their decline in abilities by preserving diversity

- A shift away from engineering has also been occurring in other developed countries. For example, even if there are promising individuals at universities in the United States, you will rarely meet one who was born in the United States. However, even this is strong overall and a direct effect of diversity.

- In the case of other developed countries, they cover drops in ability with diversity, and by doing so, attain further diversity and the added value and abilities that come with it.

● Desire for the creation of mechanisms that will breed diversity

- It is important to come up with mechanisms that will naturally produce diversity. These mechanisms should be concerned with the presence of diversity at universities, how to stimulate governance, knowing how the world is trending, what moves result in money, and how to gather people together. It is necessary for Japan to show a bit of success with some of these.

● That we should absorb foreign knowledge (send young and promising researchers overseas and summon promising foreign researchers to Japan)

- About 30 years ago, Korea acted to send all of its science and technology university teachers on yearlong study abroad trips to the United States, Japan, or Europe. The result of that was rapid development due to the foreign research subjects they brought back with them to Korea. In this way, a compulsory measure that sends researchers overseas for a year could do nothing but help. If you send as many young and promising researchers as possible overseas, the activities they engage in there should be considered good even if they opt not to return to Japan. Also, in order to educate Japan's young, we need to summon promising individuals from overseas. Are ideas like this not a good place to start?

- We should not do anything unreasonable to force Japanese university students into engineering departments. It is thought that the promising individuals we really need should just be summoned from overseas. Japan is the only developed country that has not done that, and it is thought to be part of the reason for the country's slump.

● We should break deadlocks by converting to a more positive way of thinking

- Once, the majority of home appliances were invented in the United States, then taken and changed by Japanese companies. Now Korea, Taiwan, and China are all doing the same things to Japan. Instead of lamenting, now is the time for us to come up with the next industry or innovation.

B) Discussion based on Presentation 2: "International Mobility of Researchers"

(1) Identification of problem areas

Figures 6-8 below were the primary focus of the discussion.

(2) Discussion issues

The discussion focused on the following issues

1. What kind of influence has the international mobility of researchers on the whole of Japanese R&D?
2. What form does the influence of international mobility of researchers take in each organization's R&D? What becomes of the organization as a result of that?
3. East Asia represents one of the world's three engineering pillars. What should Japan's global personnel development strategy be with regard to future Asian expansion?
4. For a Japanese industry heading toward globalization, what level of international experience is necessary for research personnel enrolled in university or graduate school?

The discussion for issue 1 was quite lively while few opinions were raised for issues 2-4.

(3) Opinions supporting the correlation between mobility and diversity

● At a time when the world's researchers started to move freely, only Japan seemed to be left behind

- Following the collapse of the Eastern Bloc in 1990, when the world's researchers started to move about freely, it is said that Japan was the only country left behind in that movement. Excluding Japan, discussions among an extremely diverse world community were occurring on every topic from how to engage in research to the establishment of research subjects.
- Modern civilization has reached a mutual understanding over differing value systems, and through mutual respect, is making a move to discover its next value system from within. Accordingly, diversity is a necessary condition for progress. Modern Japan really needs it as well.

● On whether a key individual is often one of the aspects in accelerating researcher mobility and if Japan is weak in that regard.

- For example, in the field of electronic devices, Taiwan and Korea had a lot of momentum between 2008 and 2009, but more time is needed to tell whether or not they will continue to change dynamically. For example, in the case of Singapore, a researcher transferred from a United States university and brought a great number of people with him/her. Korea and Taiwan, having had similar experiences, made good connections, and their ability exchange research information on the international level reached historic heights. It should be understood that today's figures are a result of that background. We should look more carefully at what causes these kinds of cycles.
- Currently, there is a lot of attention on Saigon in Vietnam. A key individual who earned lot of experience in Silicon Valley has returned, and it seems like things may start to change from here on out. Japan does not lack volume; it lacks a star player. Maybe there is some reason why Japan is unable to produce such a person.
- Japan still gives off the impression of some degree of volume. However, Japan gives off a sense of volume but it lacks that starring individual. Compared to countries and organizations that have low volume but cast a large shadow due to the presence of a key individual, Japan seems bloated by comparison.

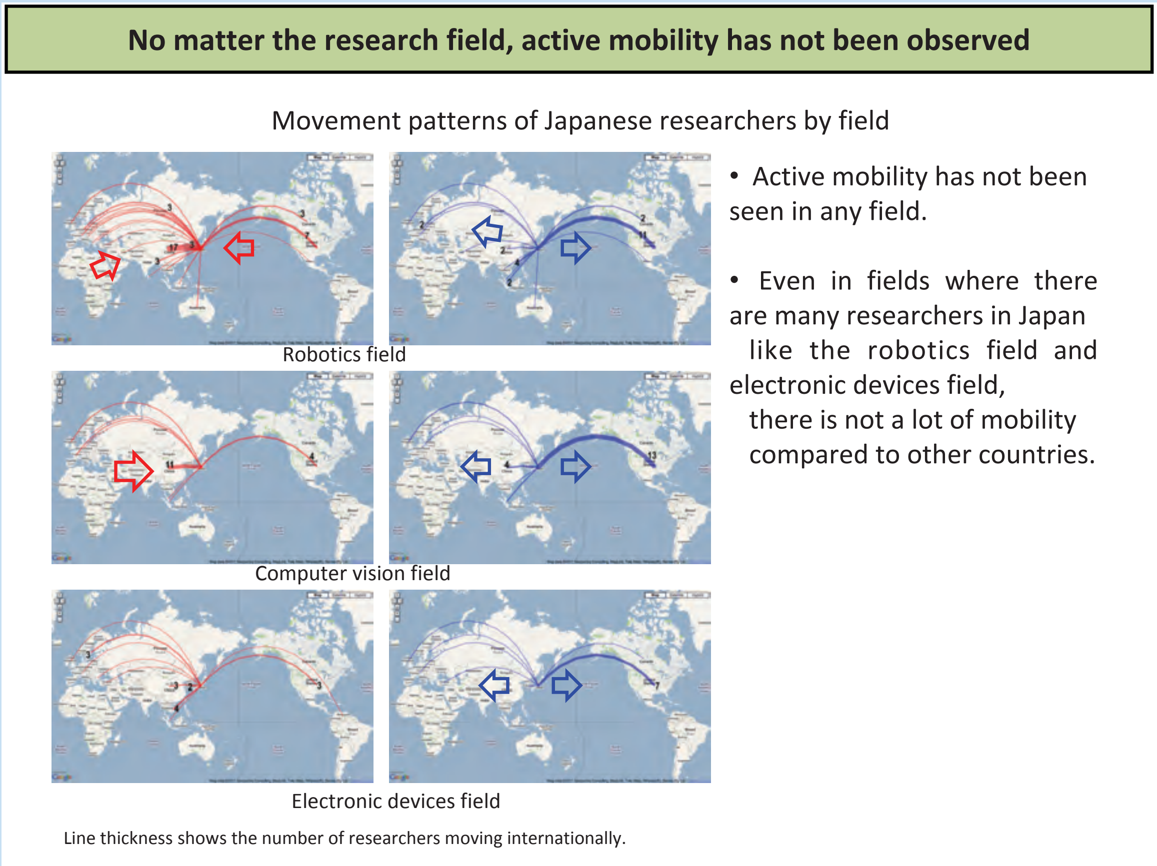

Figure 6 : Movement patterns of Japanese reseachers

From Presentation 2/Reference[4]

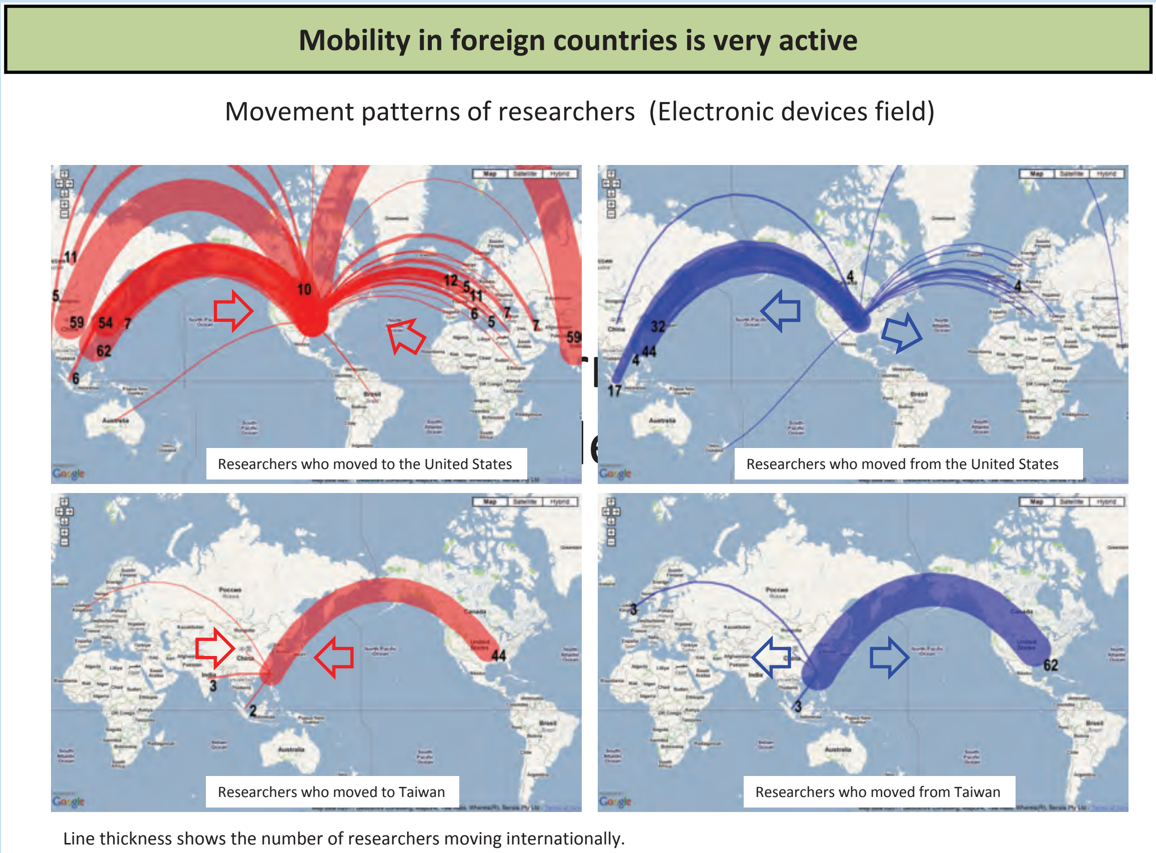

Figure 7 : Movement patterns of foreign researchers (Electronic device field)

From Presentation 2/Reference[4]

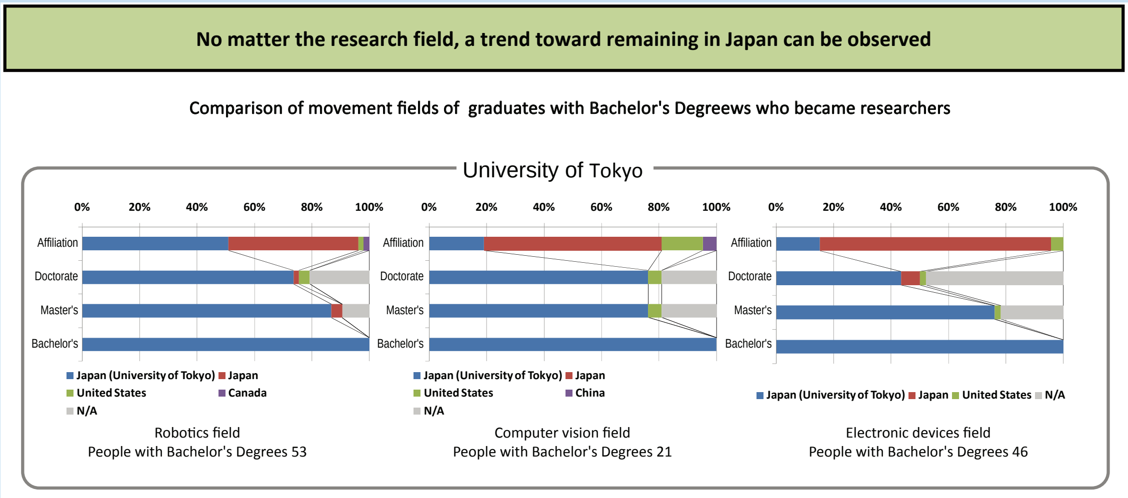

Figure 8 : Trajectories of Japanese reseachers who graduated from the University of Tokyo

From Presentation 2/Reference[4]

(4) Opinions doubting the correlation between mobility and diversity

● Measuring mobility by frequency

- Can the meaning of high international mobility, including how it occurs, be discussed just by looking at frequency?
- Even China and Hong Kong’s original social systems have been based on international mobility. A separate discussion is necessary for R&D.

● You cannot just say that because mobility is high that diversity is high

- Can you clearly say that if mobility is high, diversity is also high? There has been talk that people who have experience moving between organizations or people who are especially mobile boast fewer achievements than those who do not move. Rather, it is thought that a stereotypical pattern persists where that sort of movement pattern represents some sort of a rut, and researchers like this just move from companies to universities after actively engaging in research and attaining senior status.
- In regard to countries with high researcher mobility, there is a need for us to carefully examine what specific changes occurred that changed them from a state of low mobility to high mobility as well as what effect that change had on their competitive powers. Perhaps, based on the conditions for high mobility possessed by those countries from the start, we should also examine whether or not something else is occurring to cause this.
- The phenomenon of a single snapshot of short-term international mobility is not worth discussing. There are cases where something is implemented, a community develops in the area it was started, and then after 10 or 20 years, some sort of dynamism emerges.

(5) Fears of what could occur in the future

● That Japan will not take the first step toward real change

-In the field of semiconductor devices, exceeding a certain density can cause revolutionary changes, and the innovative abilities of a period can expand greatly in a non-linear fashion. If Japan cannot find such a “potential change of circumstances”, is it not nearly impossible for Japan to progress to the next stage?

(6) Suggestions for the future

● Making network formation into an important factor

- Network externality is strong with electronics and telecommunication products. It is also important in their R&D. If the ring of this trend continues to expand and eventually hits critical mass somewhere, does it not bring about an instant increase in benefit? This is not a regional problem. It is the process through which the network is formed that is important, and it feels as if Japan has been left behind in this regard.
- If there is a way to improve networking outside of mobility, could strengthening it allow us to cover for our current circumstances?
- When some sort of network externality appears and a network is formed within that world, entire trends actually gravitate as if they are being pulled by the effect of that network. The exchange of meta-information is extremely effective in improving networking (see Note 2 below).

Note 1: The speaker, with regard to the R&D "network externality" in this discussion, is not only referring to the networking of products that resulted from R&D. If an R&D organization networks, it can give birth to dominant competitive power. Namely, this is to be recognized for having produced the de facto standard.

● The wisdom of the humanities and social sciences

- Shortly, a number of Japanese industries may encounter a "potential change of circumstances" that requires them to listen to the wisdom of individuals versed in the humanities and social sciences in addition to scientists and engineers. I wonder if the history we have been facing up until now is the drop in competitive power that will bring us to that stage.

● The need to reconsider research boundaries

- Do you think that Japanese boundaries can be thought of simply in terms of what is on this island? For example, in 2001, Microsoft created a research institute in Beijing, and a number of Japanese researchers transferred there. There, a research environment similar to the ones in Japan was created and, despite its location in China, Japanese researchers conduct research in the same way Japanese researchers conduct research back in Japan. This small part of China has been brought closer to Japan. Research can be conducted freely, and a number of Japanese students are conducting a variety of research and engaging in discussions there.

C) Discussion regarding opinions that deserve a closer look

(1) Discussion issues

1. If you assume that there are factors beyond personnel mobility that are greatly impacting Japanese R&D, what do you think they are?
2. What kinds of strategies come to mind in terms of global personnel development at various centers/organizations?
3. Is some sort of numeric goal necessary? If you think it is necessary, where and how should we establish this goal?

The discussion primarily focused on issues 1 and 2, while almost no opinions were raised regarding issue 3.

(2) Opinions presented

● IEEE, which differs from Japanese scholarly societies in its basic administration and also possesses a business-oriented perspective

- The roles of Japanese scholarly societies are simply limited to transactions and conferences. On the other

hand, IEEE simultaneously functions as a union to some degree, helping electrical/electronic engineers search for jobs or transfer. This part in particular seems to be lacking in Japan.
- IEEE is an NPO and thinks of its existence on its own. In other words, it is constantly asking itself, “who is your customer?” For that reason, the publishing of materials that can be read and understood by normal people is fundamental. By being customer-oriented in this way, they can function to some degree in a business-oriented sense as well. Japanese scholarly societies need the same thing. If they do not develop it, can they continue to function?
- They cannot receive donations from particular companies. They are prohibited from providing profits to any standards or anything else. In Japan as well, scholarly society management styles should add features that are now common practice around the world like IEEE.

● The ability of scholarly societies to provide a place for the exchange of ideas
- IEEE Computer Society is a scholarly society with as many as 200,000 affiliated members, and with branches in each country, it has been providing places where people can gather to exchange ideas.

● The importance of guidance through the setting of common goals
- In the United States, there is the extremely simple goal of trying to be the best in the world, and scholarly societies have been working as professional societies for the purpose of that sort of education or goal.
- In the past example of the applied physics in Japan, a number of researchers from a variety of fields got together and made it their goal to beat the United States, particularly, to beat Bell Labs, the best in the United States at that time. Under a common goal, they were able to get the technological best out of the whole of Japan, and working with the common purpose of surpassing the United States, were actually able to do it temporarily. If you aim low with the goal you set, you will never achieve anything higher than that level. It is important for scholarly societies to make it their goal to be the best, and if they do, I expect that they will work extremely well as professional societies.

● IEEE’s transformation into a virtual society
- A network-based virtual society has been constructed at IEEE. In the future, it will develop in the capacity of a 2-dimensional organization structure.

● The importance of providing meta-information
- At IEEE, a real commitment is made toward standardization activities, and the scholarly society performs its roles in a variety of forms. Through those activities, it is thought that we need to be better able to see the parts we are doing ourselves in a more “meta” way. If we lack such meta-information, we tend to stubbornly adhere to the same results. We should discuss how to provide meta-information.
- The magazine Spectrum and American Physical Society’s weekly review have been reporting on trends in a form that is accessible to even novices. Is it not necessary for meta-information to be reported in this fashion for people who are not researchers? If that sort of avenue does not exist, scientific techniques cannot be discussed within social science research. Looking for that sort of thing in Japan is no small task.
- The speed of change will not increase unless you report what is happening in the form of meta-information.

Note 2: By “meta-information,” the speaker is referring to “the abstract perspective of upping the appearance of the activities you’re engaged in a notch as if in response to being watched by third parties” and “raising the level of abstraction of the significance/meaning of research results to make them more accessible to a greater number of individuals.”

● The importance of "people"

- Japan's biggest problem is that it lacks the concept of what to do with each and every one of its "people." The focus of attention overseas is fundamentally on "people." In even the case of mergers and acquisitions, it is not just about profit. It is considered effective because the "people" move together. Japan does not really have that kind of concept. In particular, teamwork is an extremely weak point of Japanese universities and graduate schools. "People" are the ones who actually conduct R&D.
- Currently, there is a lot of attention on Saigon in Vietnam. A key individual who earned lot of experience in Silicon Valley has returned, and it seems like things may start to change from here on out. Japan lacks the movement of this sort of star player. The problem has to do with why Japan is unable to do this and what the reason behind this inability might be.
- Japan still gives off the impression of some degree of volume. However, it lacks that "star person."

● Enhancing information transmission to countries overseas

- More efforts need to be made toward transmitting information abroad or accurately receiving information in Japan.

● A change in thinking based on the geographic significance of Japan's location

- Japan personally thinks itself to exist in a remote area. There are reasons that Japan is strong that are expressly related to its remote location, but the fact that we are not putting forth the effort to capitalize on

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Profile

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Received his present post after working at companies in R&D of CAD for computer design, the field of high performance computing, and business development for the field of ubiquitous computing. He is interested in the science and technology trends of supercomputers, LSI design technology, etc. Currently, he is conducting research into "science of science and innovation policy" and is striving for the quantification/visualization of social/economic results of R&D.

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